Installation Restoration Program (IRP)
Final Phase I Remedial Investigation Report

143rd Combat Communications Squadron
Seattle Air National Guard Station
Washington Air National Guard
Seattle, Washington

May 1998

Air National Guard Readiness Center
Andrews AFB, Maryland

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Prepared For:

Air National Guard Readiness Center
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LIST OF ACRONYMS

Acronym	Definition
AGE	Aerospace Ground Equipment
ANG	Air National Guard
ANG/CEVR	Air National Guard Readiness Center/Installation Restoration Program Branch
ANGS	Air National Guard Station
AOC	Area of concern
ARAR	Applicable or relevant and appropriate requirement
ASTM	American Society for Testing and Materials
AWQC	Ambient Water Quality Criteria
bgs	Below ground surface
CCSQ	Combat Communications Squadron
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
COC	Contaminant of concern
COPC	Contaminant of potential concern
CPF	Carcinogenic Potency Factor
DCE	Dichloroethene
DERP	Defense Environmental Restoration Program
EDR	Environmental Data Resources, Inc.
EE/CA	Engineering Evaluation/Cost Analysis
ERM	Environmental Resources Management
FS	Feasibility Study
GPR	Ground penetrating radar
INH	Inhalation correction factor
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program
kg	Kilograms
Koc	Organic carbon/water partition coefficient
LTM	Long-term monitoring
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
mg/kg	Milligrams per kilogram
mg/l	Milligrams per liter
µg/l	Micrograms per liter
MTCA	Model Toxics Control Act
NPDES	National Pollutant Discharge Elimination System

LIST OF ACRONYMS

Acronym	Definition
OpTech	Operational Technologies Corporation
PA	Preliminary Assessment
PA/SI	Preliminary Assessment/Site Inspection
PCE	Tetrachloroethene
pCi/l	PicoCuries per liter
PID	Photoionization detector
PREE/CA	Presumptive Remedy Engineering Evaluation/Cost Analysis
PSG	Project screening goal
QA	Quality assurance
QA/QC	Quality assurance/quality control
QC	Quality control
RA	Remedial Action
RCRA	Resource Conservation and Recovery Act
RD	Remedial Design
RfD	Reference Dose
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SI	Site Inspection
SMCL	Secondary Maximum Contaminant Level
SVOC	Semivolatile organic compound
TCE	Trichloroethene
TPH	Total petroleum hydrocarbons
TSD	Treatment, storage, or disposal
UCL	Upper confidence limit
USEPA	United States Environmental Protection Agency
VOC	Volatile organic compound
WAC	Washington Administrative Code
WDOE	Washington Department of Ecology
WTPH-D	Washington total petroleum hydrocarbons as diesel
WTPH-G	Washington total petroleum hydrocarbons as gasoline
WTPH-HCID	Washington total petroleum hydrocarbons identification method
WTPH-HO	Washington total petroleum hydrocarbons as heavy oil

EXECUTIVE SUMMARY

As part of the Department of Defense Installation Restoration Program (IRP) used to investigate potentially contaminated sites on Air National Guard property, Environmental Resources Management (ERM) conducted a Remedial Investigation at the Washington Air National Guard's Seattle Air National Guard Station (Seattle ANGS). The Seattle ANGS is located on a 7.5-acre parcel of land in the northwest portion of the King County International Airport (Boeing Field) in Seattle, Washington. A Preliminary Assessment/Site Inspection conducted at the Seattle ANGS in 1995 recommended further investigation of the site's area of concern, hereafter referred to as IRP Site 1 - Burial Site.

The Remedial Investigation included the collection of storm sewer catch basin samples, surface and subsurface soil samples, and groundwater samples. Aquifer tests were also conducted to estimate the hydraulic conductivity of the shallow aquifer beneath the site.

Soil samples collected during the Remedial Investigation suggest that the near surface geology at the Seattle ANGS is composed of approximately 8 feet of silty sand fill material underlain by a fine sand that is uniform to at least the maximum depth explored during the Remedial Investigation.

Groundwater at the Seattle ANGS occurs in a shallow, unconfined aquifer. The predominant direction of groundwater flow is toward the south. Calculated hydraulic conductivities for the shallow aquifer range from 1.25×10^{-4} to 6.09×10^{-4} feet per second (3.29 to 16.04 meters per day).

Constituents detected in soil at the Seattle ANGS include: volatile organic compounds (a single detection of trichloroethene); total petroleum hydrocarbons as gasoline, diesel, and heavy oil; trace metals; and radionuclides. The volatile organic compounds and total petroleum hydrocarbons detected in soil appear to be limited in lateral and vertical extent; in most cases, detections of volatile organic compounds and total petroleum hydrocarbons are limited to a single soil sample from a single location. The concentrations of trace metals and radionuclides detected are consistent with naturally occurring background concentrations.

Constituents detected in groundwater at the Seattle ANGS include: volatile organic compounds (acetone, benzene, toluene, ethylbenzene,

xylenes, cis-1,2-dichloroethene, 1,1-dichloroethane, 1,2-dichloroethane, 1,3,5-trimethylbenzene, 1,1,1-trichloroethane, trichloroethene, and tetrachloroethene), trace metals, and radionuclides. Most of the volatile organic compound detections in groundwater were in the southern portion of the Station. Volatile organic compounds were also detected in a groundwater monitoring well in the northwest corner of the Station used to evaluate site-specific background concentrations. As with the soils, the trace metals and radionuclides detected in groundwater appear to be representative of naturally occurring background concentrations.

Project screening goals for constituents detected in site-characterization soil and groundwater samples were developed from regulatory criteria and site-specific background concentration data. With the exception of radionuclides and arsenic, which were detected at concentrations consistent with background concentrations, only benzene and trichloroethene in groundwater were detected at concentrations exceeding the project screening goals. Based on a statistical screening evaluation of the groundwater data for these two constituents, only trichloroethene was found to not comply with the associated regulatory criterion.

A baseline risk assessment was conducted to assess the potential human health risks associated with the observed concentrations of trichloroethene in groundwater at the Seattle ANGS. The results of the baseline risk assessment indicate that the potential risks associated with ingestion and inhalation of the trichloroethene in groundwater (the reasonable maximum exposure scenario assumed for the site) exceed the State and Federal acceptable levels for excess cancer risk.

Further investigation of site soil and groundwater is recommended to determine the source and extent of the volatile organic compounds detected in groundwater. In addition, the investigation should include quarterly groundwater monitoring.

SECTION 1.0

INTRODUCTION

This report describes the Remedial Investigation (RI) conducted at the Seattle Air National Guard Station (Seattle ANGS) in Seattle, Washington. The RI was conducted as part of the Air National Guard (ANG) Installation Restoration Program (IRP) under Contract DAHA90-94-0014, Delivery Order 32. The Air National Guard/Civil Engineering Environmental Restoration Group (ANG/CEVR) provided technical and project management oversight for this investigation on behalf of the ANG. The RI report follows the recommended ANG/CEVR format and contains the basic contents suggested in the United States Environmental Protection Agency (USEPA) document *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA, 1988).

Field activities for the RI were performed from September 1996 through July 1997. The objectives of the RI were to: 1) evaluate the nature and extent of potential contamination related to IRP Site 1 - Burial Site (the IRP site); 2) assess site-specific background concentrations of potential contaminants of concern in soil and groundwater; and 3) provide recommendations for additional remedial actions as appropriate.

1.1 Report Organization

This RI Report provides a summary of the activities for the RI and is organized into 11 sections and 10 appendices. The contents of the sections are as follows:

- Section 1.0 provides general introductory information for this report;
- Section 2.0 provides background information for the Seattle ANGS;
- Section 3.0 summarizes the environmental setting in the vicinity of the Seattle ANGS;
- Section 4.0 describes the field investigation program;

- Section 5.0 describes the investigation findings;
- Section 6.0 discusses Federal and State applicable or relevant and appropriate requirements (ARARs);
- Section 7.0 discusses contaminant fate and transport;
- Section 8.0 discusses risk assessment;
- Section 9.0 presents conclusions;
- Section 10.0 presents recommendations; and
- Section 11.0 lists references.

The following appendices are included with this report:

- Appendix A contains technical memoranda for field activities;
- Appendix B contains borehole logs and well construction diagrams;
- Appendix C contains location and elevation survey data;
- Appendix D contains recommendations for the disposition of investigation derived wastes;
- Appendix E contains aquifer test data;
- Appendix F lists the repositories of laboratory analytical data packages;
- Appendix G contains total petroleum hydrocarbons (TPH) field-screening results;
- Appendix H contains a letter from the Washington Department of Ecology (WDOE) regarding radionuclides in soil;
- Appendix I contains copies of the analytical data summary sheets (sample results) from the laboratory data packages; and
- Appendix J contains analytical data review and validation reports.

1.2 Site Background Information

The Seattle ANGS is at 6736 Ellis Avenue South in Seattle, Washington (Figure 1-1). The Station occupies approximately 7.5 acres of land in the northwest portion of the King County International Airport (Boeing Field) (OpTech, 1995).

Previous IRP investigations have been performed at the Seattle ANGS. These investigations include the following:

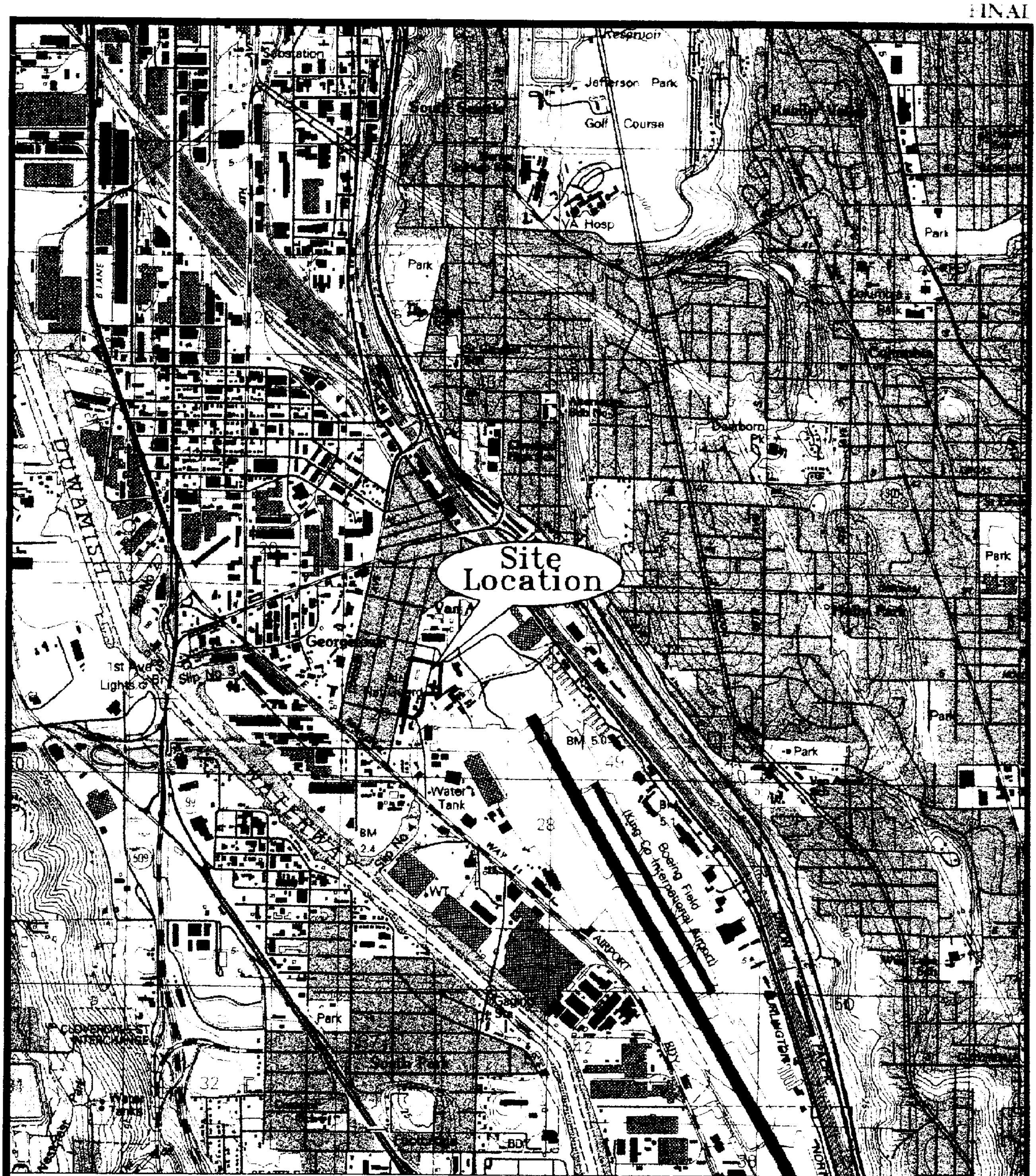
- A Preliminary Assessment (PA) was completed in 1993 by the ANG.
- A Preliminary Assessment/Site Inspection (PA/SI) was completed in 1994 by Operational Technologies Corporation (OpTech).

The PA/SI report recommended further investigation of the IRP site to determine the source and areal extent of TPH contamination detected in soil samples and gross alpha and gross beta radiation detected in soil and groundwater samples. The PA/SI report also noted that State action levels were exceeded for several trace metals, but concentrations of those metals did not exceed site-specific background concentrations except for beryllium in groundwater.

1.3 Installation Restoration Program Information

The Defense Environmental Restoration Program (DERP) was established in 1984 to promote and coordinate efforts for the evaluation and cleanup of contamination at Department of Defense installations. On January 23, 1987, Presidential Executive Order 12580 was issued which assigned the responsibility for carrying out DERP within the overall framework of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and the Superfund Amendments and Reauthorization Act of 1986 (SARA) to the Secretary of Defense. The IRP was established under DERP to identify, investigate, and remediate contamination at installations. The IRP focuses on cleanup of contamination associated with past Department of Defense activities to ensure that threats to public health are eliminated and to restore natural resources for future use.

The IRP is divided into several phases as illustrated on Figure 1-2. These phases are defined and described in the following subsections.



From USGS 7.5 Minute
Topographic Map Series
Seattle South, Washington

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FIGURE 1-1	LOCATION MAP OF SEATTLE AIR NATIONAL GUARD STATION SEATTLE, WASHINGTON 143rd CCSQ, Seattle ANGS Seattle, Washington	ERM

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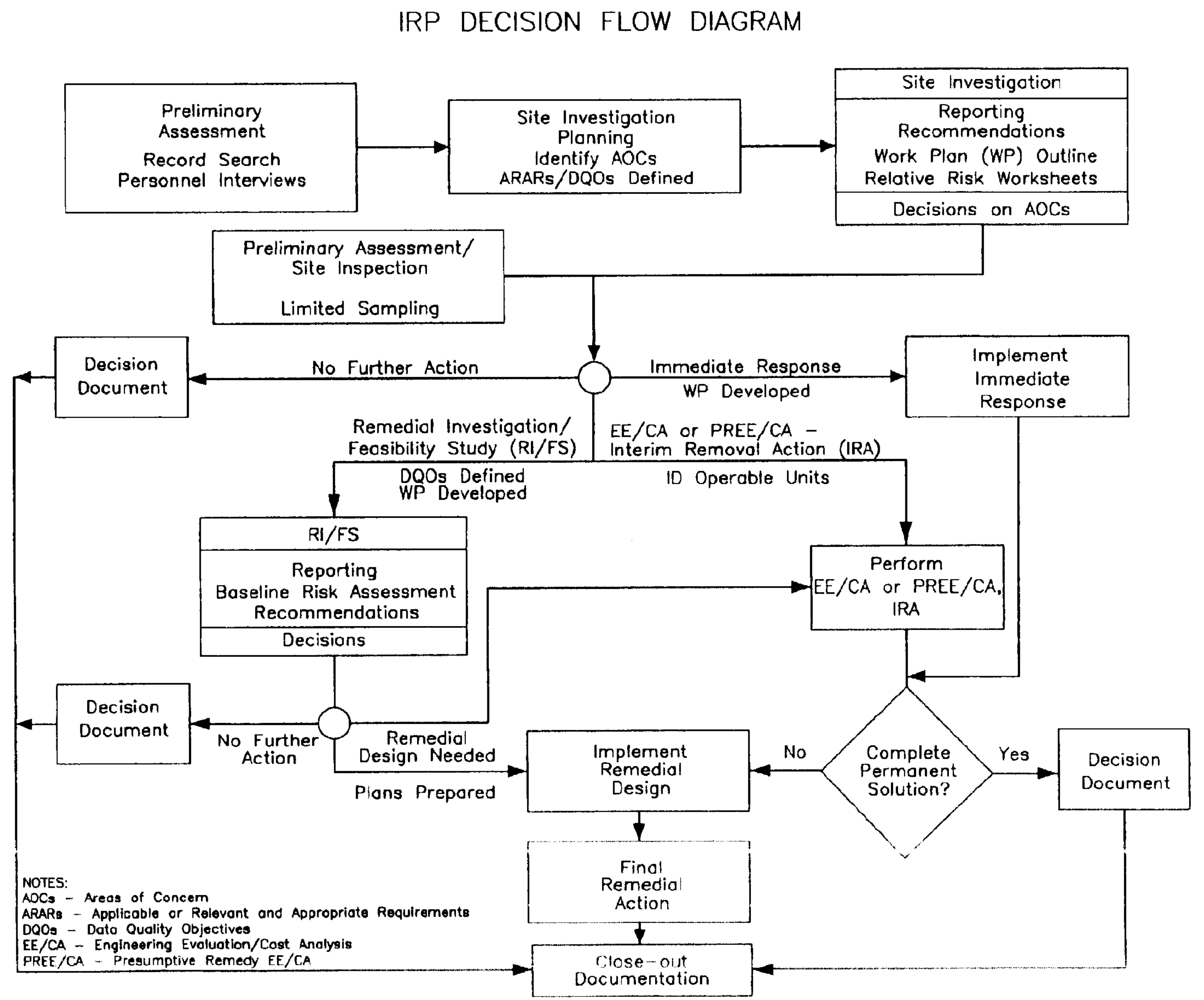

NOTES:
AOCs – Areas of Concern
ARARs – Applicable or Relevant and Appropriate Requirements
DQOs – Data Quality Objectives
EE/CA – Engineering Evaluation/Cost Analysis
PREE/CA – Presumptive Remedy EE/CA

FIGURE 1–2

INSTALLATION RESTORATION PROGRAM DECISION FLOW DIAGRAM

143rd CCSQ, Seattle ANGS
Seattle, Washington

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1.3.1 Preliminary Assessment

The PA consists of personnel interviews and a record search designed to identify and evaluate past disposal and/or spill sites that might pose a potential or actual hazard to public health, public welfare, or the environment. Previously undocumented information is obtained through the interviews. The record search focuses on obtaining useful information from: aerial photographs; installation plans; facility inventory documents; lists of hazardous materials used; subcontractor reports; correspondence; Material Safety Data Sheets; federal/state agency scientific reports on endangered and threatened species and critical habitats; documents from local government offices; and numerous standard reference sources.

1.3.2 Site Inspection

The purpose of the Site Inspection (SI) is to perform limited sampling and other field activities to confirm the presence or absence of contamination at potential areas of concern (AOCs) identified during the PA. This may include, for example, geophysical surveys, field-screening, soil sampling, and limited groundwater sampling for suspected contaminants. The SI may be conducted in conjunction with the PA. Data collected during the PA and SI may be sufficient to reach a decision point for a site, such as no further IRP action is warranted, prompt removal of contaminants is necessary, or further IRP work is required.

1.3.3 Site Investigation

Like the SI, the Site Investigation consists of field activities designed to confirm the presence or absence of contamination at potential AOCs identified during the PA. However, the Site Investigation typically includes more extensive sampling and evaluation of groundwater than the SI. An additional objective of the Site Investigation is to determine potential risks to human health and the environment.

The activities undertaken during the Site Investigation generally fall into three categories: screening, confirmation, and optional activities. Screening activities are conducted to gather additional preliminary data not obtained during the PA. Confirmation activities include specific media sampling and laboratory analysis to confirm either the presence or the absence of contamination, chemical concentrations, and the potential for migration of contaminants. Information obtained during the subsurface investigation is utilized to define AOCs from among the potential AOCs identified during the PA. Site hydrology, geology, and soil properties are also characterized during the Site Investigation. Additional data may be needed to reach a decision point for a site. Optional activities may be conducted to obtain the additional data needed.

The general approach of the Site Investigation is to sequence the field activities so that data are acquired and used as the field investigation progresses. This is done to determine the presence or absence of contamination in a relatively short time period, optimize data collection and data quality, and minimize costs.

1.3.4 Remedial Investigation

The objectives of the RI are to determine the nature and extent of contamination at a site, determine the nature and extent of potential threats to human health and the environment, and provide a basis for determining the types of response actions to be considered (Decision Document, Feasibility Study [FS], Remedial Design [RD], or Remedial Action [RA]).

The RI consists of field activities designed to quantify the potential contaminant, the extent of the contamination, and the pathways of contaminant migration. Field activities may include the installation of soil borings and/or monitoring wells and the collection and analysis of water, soil, and/or sediment samples. Careful documentation and quality control procedures are implemented during RI field activities in accordance with CERCLA/SARA guidelines which ensure the validity of data.

Hydrogeologic studies are conducted to determine the underlying strata, groundwater flow rates, and direction of contaminant migration.

A baseline risk assessment, which provides an evaluation of the potential threat to human health, is conducted prior to implementing any RA. The baseline risk assessment provides the basis for determining whether an RA may be necessary to mitigate endangerment to public health.

The findings from the RI will result in the selection of one of the following options:

- No Further Action: The results of investigations do not indicate harmful concentrations of chemicals that pose a significant threat to human health or the environment. Therefore, no further IRP action is warranted and a decision document will be prepared to close the site.

- Long-Term Monitoring (LTM): The results of investigations do not indicate the presence of sufficient contamination to justify costly RA. LTM may be recommended to detect the possibility of future problems.

- FS: The results of investigations confirm the presence of contamination that may pose a threat to human health and/or the environment, and some sort of RA is indicated.

1.3.5 Feasibility Study

Based on results of the RI, the baseline risk assessment, and a review of state and federal regulatory requirements, an FS may be conducted to develop, screen, and evaluate alternatives for remediation of groundwater and/or soil contamination at the site. The overall objectives of the FS include providing information necessary for remedial alternative development and evaluating information to support selection of a remedy that is protective of human health and the environment; considers ARARs; satisfies the preference for treatment that significantly and permanently reduces toxicity, mobility, or volume of hazardous constituents as a principal element; and is cost-effective.

Activities associated with the FS include the following:

- Identification of applicable remediation technologies/RAs;

- Preliminary screening of technologies;

- Development and screening of remedial alternatives;

- Detailed analysis of alternatives;

- Comparative analysis of alternatives; and

- Completion of an FS report.

The end result of the FS is the selection of the most appropriate remedial alternative with concurrence by state and/or federal regulatory agencies.

1.3.6 Engineering Evaluation/Cost Analysis

At any time during the course of an IRP project, an Engineering Evaluation/Cost Analysis (EE/CA) can be implemented to evaluate remedial solutions for contamination. An EE/CA can be completed for all non-time-critical removal actions that are not addressed by an FS. In general, an EE/CA is similar to a Remedial Investigation/Feasibility Study (RI/FS) but is less comprehensive because of the presumption of an RA. An EE/CA is usually completed as a parallel effort to an RI/FS. The overall objectives of the EE/CA include satisfying environmental review and administrative requirements for removal actions; providing a framework for evaluating and selecting alternative technologies; satisfying the preference for a treatment that significantly and permanently reduces toxicity, mobility, or volume of hazardous constituents as a principal element; and maximizing cost-effectiveness

The goals of the EE/CA are to:

- Develop an Approval Memorandum;
- Identify removal action objectives;
- Identify and analyze removal action alternatives;
- Compare removal action alternatives; and
- Recommend removal action alternatives in an Action Memorandum.

The end result of the EE/CA is the selection of the most appropriate removal action with concurrence by state or federal regulatory agencies.

1.3.7 Presumptive Remedy Engineering Evaluation/Cost Analysis

A Presumptive Remedy Engineering Evaluation/Cost Analysis (PREE/CA) may be performed if the results of investigations indicate the presence of sufficient contamination to justify an RA prior to completion of an FS, and the technology required for the RA is evident. A PREE/CA may be recommended to evaluate the effectiveness and costs associated with the presumptive RAs.

1.3.8 Remedial Design

The RD involves development and approval of the engineering designs required to implement the selected remedial alternative identified in the FS.

1.3.9 Remedial Action

The RA is the actual implementation of the remedial alternative. It refers to the accomplishment of measures to eliminate the hazard or, at a minimum, reduce it to an acceptable limit. Covering a landfill with an impermeable cap, pumping and treating contaminated groundwater, installing a new water distribution system, and in situ biodegradation of contaminated soils are examples of remedial measures that might be selected. In some cases, after the RAs have been completed, an LTM system may be installed as a precautionary measure to detect contaminant migration or to document the efficiency of remediation.

1.3.10 Immediate Action Alternatives

At any point, it may be determined that a site poses an immediate threat to public health or the environment, thus necessitating prompt removal of the contaminants. Immediate action, such as limiting access to the site, capping or removing contaminated soils, and/or providing an alternative water supply may suffice as effective control measures. Sites requiring immediate removal action maintain IRP status in order to determine the need for additional remedial planning or LTM. Removal measures or other appropriate RAs may be implemented during any phase of an IRP project.

SECTION 2.0

SITE BACKGROUND INFORMATION

This section of the RI Report provides a description of the Seattle ANGS and a summary of previous investigations at the site. Information presented in this section was derived primarily from OpTech's report entitled *Installation Restoration Program, Preliminary Assessment/Site Inspection Report, 143rd Combat Communications Squadron, Seattle Air National Guard Station, Washington Air National Guard, Seattle, Washington* (OpTech, 1995). This information has been updated based on the RI findings.

2.1 Facility Description

The Seattle ANGS is at 6736 Ellis Avenue South in Seattle, Washington. The Station presently occupies approximately 7.5 acres of land in the northwest portion of the King County International Airport (Boeing Field). The facility employs 129 personnel, of which 25 are full-time employees. A plan of the site is shown on Figure 2-1.

2.1.1 Station History

The Seattle ANGS was built during World War II by the War Department and was used by the Army Air Force as the "Aircraft Factory School" during the war. In 1948, the property was given to King County as surplus property and was subsequently leased to the Washington Air National Guard (OpTech, 1995).

On April 21, 1948, the 143rd Aircraft Control and Warning Squadron was established. From May 1951 to February 1953, the 143rd was activated for recruitment purposes. During this period of time, the unit had two C-47 aircraft. In 1960, the name of the unit was formally changed to the 143rd Communications Squadron Tributary Teams. In 1969 and 1988, the name of the unit was again changed, becoming the 143rd Mobile Communications Squadron and the 143rd Combat Communications Squadron (CCSQ), respectively.

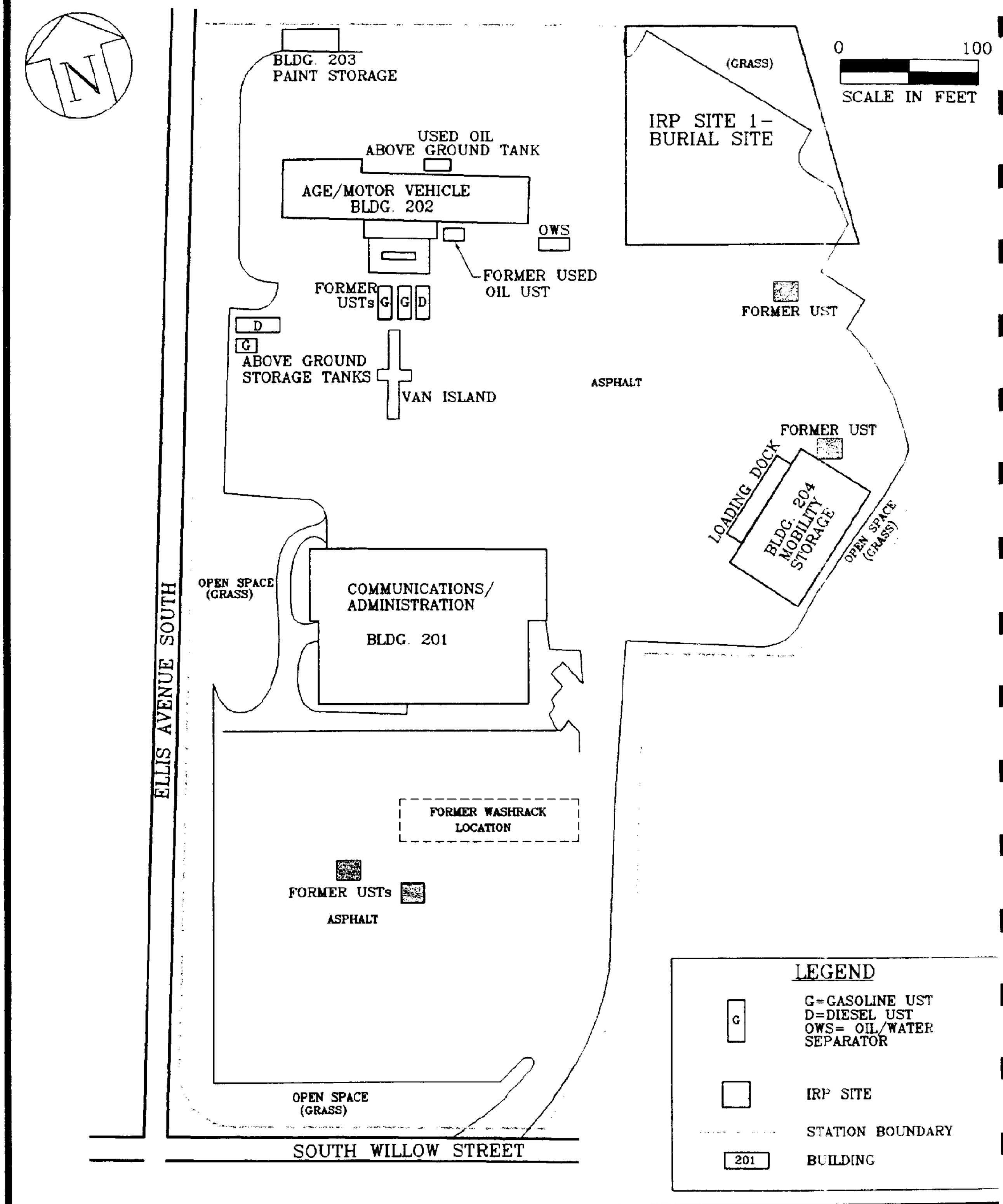

FIGURE 2-1

SITE PLAN

143rd CCSQ, Seattle ANGS
Seattle, Washington

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The current mission of the 143rd CCSQ is to provide mobile communication equipment and support for airports and airfields (OpTech, 1995).

In 1948, the Station consisted of 17 acres of land, including an aircraft parking ramp, leased from King County. At that time, the property contained 15 buildings (including a number of small shed structures), all of which were subsequently demolished. In 1951, a new property lease decreased the size of the Station from 17 acres to its present size of 7.5 acres. Buildings were constructed for headquarters, a mess hall, warehouses, and vehicle service requirements. In 1980, the National Guard Bureau approved and Congress funded $2.3 million for the replacement of all buildings. The buildings were completed in 1984, with the exception of the Mobility Warehouse, which was completed in 1988. Seattle ANGS now consists of 7.5 acres and four buildings (34,698 total square feet). The Seattle ANGS property is leased from King County by the United States Air Force, who in turn licenses the property to the Washington State Military Department for ANG use (OpTech, 1995).

2.1.2 Adjacent Land Use

Land use adjacent to the Seattle ANGS is shown on Figure 2-2. Adjacent properties to the north, south, and east of the Station are zoned for general industrial use, are currently used for industrial purposes, and have a history of industrial use. The properties directly east and south of the Station are owned by The Boeing Company (Boeing) or leased by Boeing from King County. The property immediately north of the Station is occupied by several trucking firms and the Washington State Motor Pool automobile maintenance facility, while the area west of the Station, across Ellis Avenue South, consists of residential properties (OpTech, 1995).

2.1.3 IRP Site 1 - Burial Site Description

As shown on Figure 2-1, the IRP site is located in the northeast corner of the Seattle ANGS. The site is approximately 175 feet long and an average of 175 feet wide. The north and east sides of the site are bounded by a 6-foot-high fence. With the exception of the grass-covered northeast corner, the site is covered with asphalt and is used as a vehicle parking area.

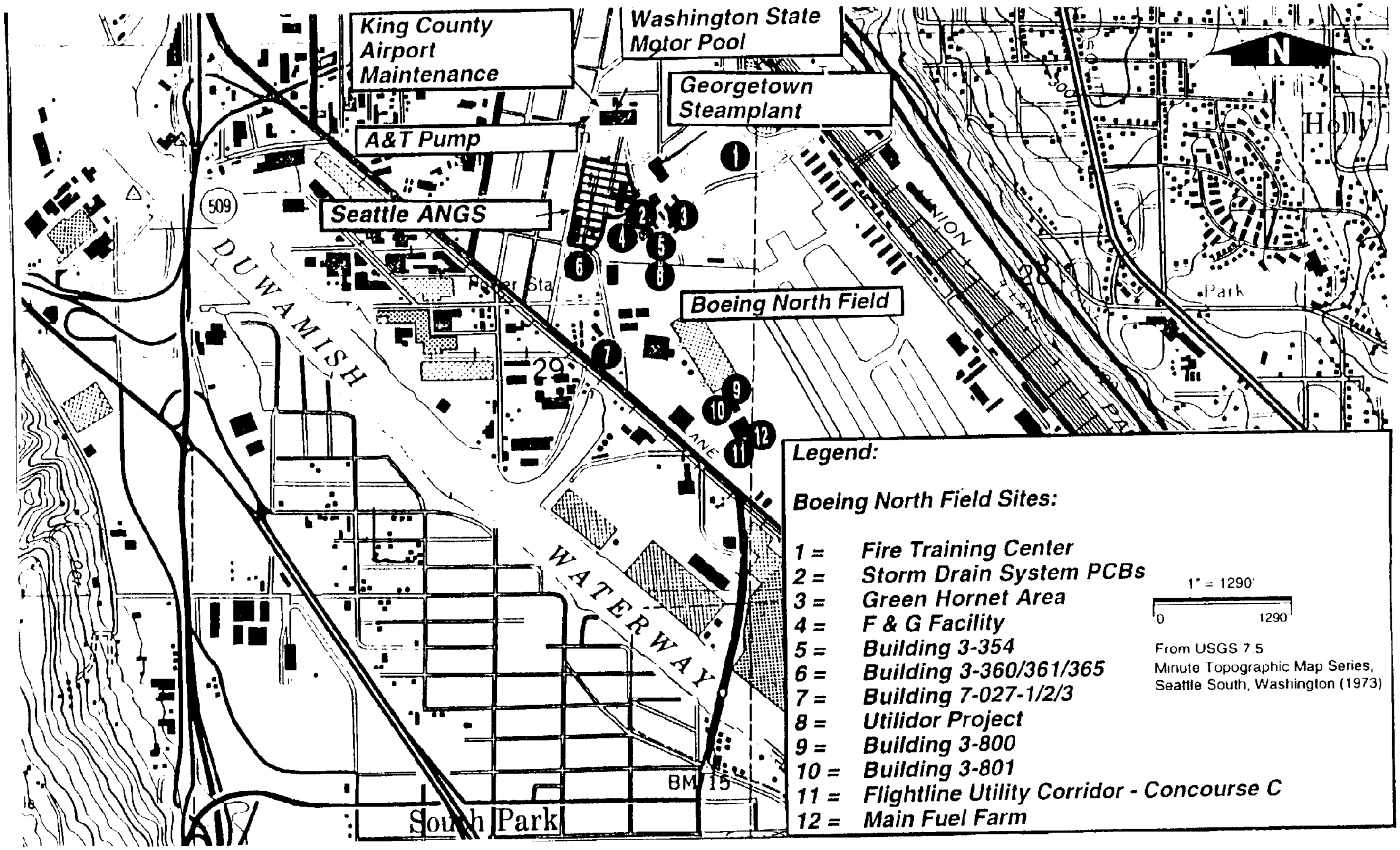

FIGURE 2-2

ADJACENT LAND USE AND SITES OF ENVIRONMENTAL CONCERN

143rd CCSQ, Seattle ANGS
Seattle, Washington

ERM

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2.2 Waste Disposal History

This section summarizes the results of the PA/SI regarding hazardous materials and wastes generated, historical and current disposal practices, and past environmental incidents and problems at the Seattle ANGS.

The information presented in the PA/SI report is based on interviews with past and present Station employees, a review of Station records and other pertinent information, and a field survey.

2.2.1 Wastes Generated by Station Operations

A variety of wastes were burned and/or buried at the IRP site from the early 1950s through 1968. The wastes most likely disposed of at this site include radio tubes, solvents, waste motor oils, kerosene, batteries, brake fluid, spray paints, paint thinners or removers, methyl ethyl ketone, xylene, and naptha. These wastes were generated by Aerospace Ground Equipment (AGE)/Motor Vehicle Maintenance, Power Production, and Communication/Administration Buildings.

2.2.2 Disposal Practices at the Station

Historical disposal practices at the Seattle ANGS included land disposal within the IRP site and off-site disposal. Presently, discarded hazardous materials and hazardous wastes are collected and disposed of either by a licensed contractor or through the Defense Reutilization and Marketing Office at Fort Lewis, Washington.

2.2.3 Past Environmental Incidents and Problems

Small amounts of hazardous materials are reported to have been spilled or released to the environment at the Station in the past. The PA/SI identified the IRP site as the only potentially contaminated disposal site at the Station. Identification of this site was based on interviews with past and present employees, an analysis of pertinent information and Station records, and a field survey.

2.3 Regulatory Records Review

The PA/SI identified several sites on properties adjacent to the Seattle ANGS with a history of environmental contamination or environmental incidents. The environmental conditions at adjacent properties were further evaluated during preparation of the RI/FS Work Plan.

An Environmental Data Resources, Inc., (EDR) summary report was prepared on the status and location of sites of environmental significance within a 1-mile radius of the Seattle ANGS. The EDR database search identified 19 sites within a 1-mile radius of the Seattle ANGS that appear on the WDOE's Confirmed and Suspected Contaminated Sites List. The EDR database search also identified 14 leaking underground storage tank sites within 1/2 mile of the Seattle ANGS. In addition, EDR identified one sensitive receptor category, a day care center, within a 1/4-mile radius of the Seattle ANGS.

The second phase of the regulatory records review included a review of WDOE's file records regarding selected sites of environmental concern. These sites of environmental concern include the following:

- Boeing Company - North Field, Ellis Avenue South & Marginal Way;
- King County Airport Maintenance, 6518 Ellis Avenue South;
- Washington State Motor Pool, 6650 Ellis Avenue South;
- Seattle City Light - Georgetown Steamplant, 1131 South Elizabeth Street; and
- A & T Pump, 6525 Ellis Avenue South.

More than one site of environmental concern exists within the Boeing Company North Field property. The locations of these sites relative to the Seattle ANGS are shown on Figure 2-2. Details regarding previous investigations and documented contamination at these sites are presented in the Phase I RI/FS Work Plan (ERM, 1996). Based on the WDOE file review, none of the environmental impacts at these sites appear to represent a potential source of significant contamination on the Seattle ANGS property.

2.4 Previous Investigations

This section summarizes previous investigations conducted as part of the IRP at the Seattle ANGS.

2.4.1 Preliminary Assessment

A Draft PA was completed by the ANG in 1993. The PA focused on past and present generation, use, handling, and disposal practices of hazardous materials and wastes at the Seattle ANGS. Based on the results of the PA, the IRP site was identified as being potentially contaminated with hazardous materials/wastes and was recommended for further IRP investigation.

2.4.2 Preliminary Assessment/Site Inspection

A PA/SI was conducted by OpTech in 1994. This section summarizes the scope of work, the results of geologic and hydrologic investigations, and the results of laboratory analyses conducted during the PA/SI. shows the locations of soil borings and monitoring wells installed during the PA/SI.

2.4.2.1 Scope of Work

The purpose of the PA/SI was to identify AOCs and to confirm the presence or absence of soil and groundwater contamination associated with past hazardous material and hazardous waste handling and disposal. The scope of the PA/SI was limited to areas under the primary control of the Seattle ANGS. The PA/SI scope of work did not include determination of the extent of contamination at the IRP site or assessment of possible threats to human health and the environment.

The PA/SI included the following activities: identifying AOCs at or under the primary control of the ANGS and evaluating potential receptors; defining the nature of releases at the identified AOC; confirming the presence or absence of soil and groundwater contamination; describing the geologic conditions of the study area, including the subsurface soil types and presence or absence of hydrogeologic confining layers, and defining hydrogeologic conditions such as groundwater flow direction.

Field work for the PA/SI was performed in June and July 1994. The PA/SI field work included the following screening and confirmation activities at the IRP site:

Screening Activities:

- Ground-penetrating radar (GPR) and magnetometer surveys; and
- Shallow soil vapor survey at 21 sampling points.

Confirmation Activities:

- Soil sampling from three soil borings and one monitoring well boring; and
- Installation and sampling of three groundwater monitoring wells.

2.4.2.2 Geophysical Investigation

A geophysical survey, using GPR and magnetometer investigation techniques, was conducted at the IRP site in June 1994.

GPR data were collected along 11 longitudinal (vertical) and 11 transverse (horizontal) traverses at the IRP site. The GPR results revealed subsurface structures and disturbed soil areas. Two underground utilities were detected in the northern and eastern areas. The possible presence of these utilities was indicated (by as-built drawings) before the survey was conducted. A large area of a different soil horizon or disturbed soil, with an upper interface at approximately 4.5 to 6.0 feet below ground surface (bgs), was detected on numerous traverses in the southwestern portion of the IRP site. The origin of this different soil material was interpreted as being associated either with the filling-in of the former Duwamish River or with the historical burial or burning activities at the site.

Magnetometer data were also collected at the IRP site. The magnetometer data indicated the presence of significant magnetic disturbances in specific areas of the site, all of which are attributable to surface interferences. The PA/SI report concluded that there were no significant magnetic disturbances present that coincided with the area of disturbed soil detected with GPR in the southwestern portion of the site. The PA/SI report also concluded that the disturbed soil area is not suspected of being an area where significant metal masses are buried (OpTech, 1995).

2.4.2.3 Soil Vapor Survey

A soil vapor survey was conducted at the IRP site to screen for the presence of volatile hydrocarbon constituents in soil. Twenty-one soil vapor samples were collected on a grid, spacing the points 30 feet apart. All soil vapor samples were collected from a depth of approximately 5 feet bgs. The soil vapor survey results were used to determine the locations for soil borings.

2.4.2.4 Soil Borings

Three soil borings, identified as BS-001BH through BS-003BH, were drilled at the IRP site to a depth of approximately 10 feet bgs (Figure 2-3). The locations of the soil borings were selected based on results of the geophysical and soil vapor surveys. The soil borings were drilled in areas of known past waste dumping, burning, and burial.

Three soil samples were collected from each of the soil borings and submitted for laboratory analysis. The soil samples were analyzed for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), TPH, polychlorinated biphenyls, gross alpha and gross beta radiation, and priority pollutant trace metals.

2.4.2.5 Monitoring Wells

Three groundwater monitoring wells, identified as BS-004PZ through BS-006PZ, were installed at the Seattle ANGS (Figure 2-3). The monitoring wells are referred to as piezometers in the PA/SI report, although the wells were used for both groundwater level monitoring and groundwater sampling. One monitoring well (BS-004PZ) was installed cross-gradient from the IRP site. Monitoring wells BS-005PZ and BS-006PZ were installed downgradient of the IRP site. The three monitoring wells were drilled to a depth of 20.5 feet bgs.

One groundwater sample was collected from each of the monitoring wells and submitted for laboratory analysis. The groundwater samples were analyzed for VOCs, SVOCs, TPH, polychlorinated biphenyls, gross alpha and gross beta radiation, and priority pollutant trace metals. Groundwater samples submitted for metals analysis were not filtered prior to analysis. Soil and groundwater samples collected from monitoring well BS-004PZ were used to determine site-specific background chemical concentrations for the site.

2.4.2.6 Geologic and Hydrologic Conditions

Soil samples collected from the soil borings and monitoring wells were used to provide information for describing the subsurface geology and soil conditions in the vicinity of the IRP site Sand, silty sand, and silty clay were the predominant materials encountered during the drilling activities. A sand and gravel fill material was encountered in the first 1 to

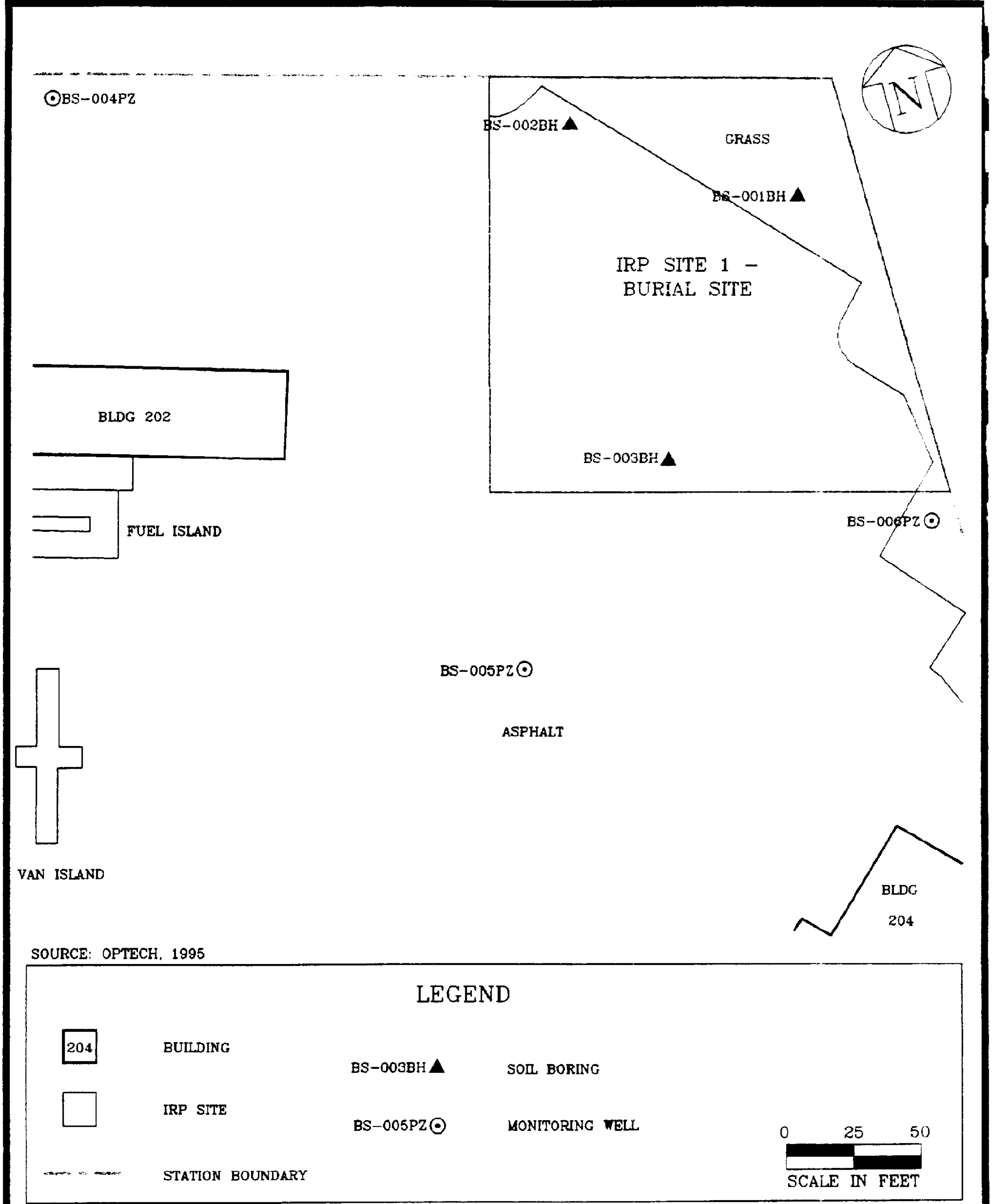

FIGURE 2-3

LOCATION OF PA/SI SOIL BORINGS AND MONITORING WELLS
143rd CCSQ, Seattle ANGS
Seattle, Washington

ERM

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2 feet bgs south and west of the IRP Site. This sand/gravel fill material was not encountered in the northern half of the IRP Site. A silty sand was encountered below the shallow fill material south and west of the IRP Site to 10 feet bgs, followed by a well sorted, medium to coarse grained sand from 10 to 20.5 feet bgs. The predominant materials encountered within the IRP Site from the surface to 4 feet bgs were silty sand and clay and clayey sand. From 4 to 10 feet bgs, silty sand was the predominant lithology encountered within the IRP Site, with a clayey sand interval at 5.5 to 7 feet bgs near the northeast corner of the IRP Site being the only exception.

Static water levels in the monitoring wells were measured during one groundwater sampling event (July 1994). Depth to water in the three monitoring wells ranged from 9.45 to 9.81 feet bgs. The inferred groundwater flow direction was toward the southwest.

2.4.2.7 Results of Chemical Analyses

Tables 2-1 and 2-2 summarize the analytical results for soil and groundwater samples collected during the PA/SI. For comparison, project screening goals developed from chemical-specific ARARs during the RI are also shown on Tables 2-1 and 2-2. Concentrations of constituents detected in site-characterization samples collected at the IRP site were compared to regional and site-specific background concentrations, Washington Model Toxics Control Act (MTCA) Method A Cleanup Levels (WDOE, 1993), MTCA Method B Formula Values (WDOE, 1994a), and/or Federal Maximum Contaminant Levels (MCLs) for drinking water.

TPH was detected at a concentration exceeding the MTCA Method A Cleanup Level in one soil sample collected from 2 feet bgs near the southern boundary of the IRP site (soil boring BS-003BH). Beryllium concentrations in all of the PA/SI soil samples exceeded the MTCA Method B Cancer Formula Value. Constituents detected in groundwater at concentrations exceeding MTCA Method A Cleanup Levels or MCLs include gross alpha and gross beta radiation, arsenic, beryllium, chromium, and lead.

One SVOC, di-n-butylphthalate, was detected in all but one of the soil samples collected during the PA/SI. The presence of di-n-butylphthalate was attributed to possible laboratory contamination of the soil samples.

TABLE 2-1

Summary of PA/SI Soil Chemical Quality Data
143rd CCSQ, Seattle ANGS, Seattle, Washington
Source: Optech, 1995

Location	Sample Depth (ft-bgs)	Volatile Organic Compounds (USEPA Method 8240) (µg/kg)	Semivolatile Organic Compounds (USEPA Method 8270) (µg/kg) di-n-butyl phthalate	Total Petroleum Hydrocarbons (WTPH-D, G) (mg/kg)	Polychlorinated Biphenyls (USEPA Method 8080) (µg/kg)	Radionuclides (USEPA Method 9310) (pCi/g)		Trace Metals (mg/kg)												
						Gross Alpha	Gross Beta	Sb	As	Be	Cd	Cr	Cu	Pb	Hg	Ni	Se	Ag	Tl	Zn
Background (BS-004PZ)	8.5 - 10.0	ND	2,240	ND	ND	0 ± 17	0 ± 32	ND	2	1.2	1.6	10	40	34	ND	13	ND	ND	0.056	25
BS-001BH	1.0 - 2.5	ND	1,750	ND	ND	4 ± 27	2 ± 35	ND	0.33	1	1.6	11	130	28	ND	14	0.053	0.18	0.038	19
	5.5 - 7.0	ND	1,680	ND	ND	0 ± 18	4 ± 36	ND	1.6	0.82	1.1	11	16	16	ND	5.8	ND	ND	0.03	8.6
	8.5 - 10.0	ND	1,590	ND	ND	0 ± 20	0 ± 24	ND	0.033	0.29	0.66	7.9	9.3	9.7	ND	5.6	ND	ND	ND	14
BS-002BH	1.0 - 2.5	ND	1,640	ND	ND	2 ± 25	3 ± 37	ND	2.7	0.87	1.3	10	23	28	ND	9.3	ND	ND	0.024	31
	5.5 - 7.0	ND	900	ND	ND	2 ± 25	0 ± 36	ND	1.1	0.49	0.92	14	23	15	ND	6.2	ND	ND	0.054	16
	8.5 - 10.0	ND	1,960	ND	ND	2 ± 25	0 ± 34	ND	0.63	0.34	0.75	9.3	7.5	10	ND	7.2	ND	ND	ND	20
BS-003BH	2.0 - 3.5	ND	ND	780*	ND	2 ± 20	2 ± 30	ND	4.1	1	1.3	11	20	27	ND	8.6	ND	ND	0.053	19
	5.5 - 7.0	ND	744	160*	ND	0 ± 21	0 ± 34	ND	20	1.1	1.5	15	33	62	ND	14	ND	0.042	0.093	40
	8.5 - 10.0	ND	1,750	ND	ND	0 ± 21	0 ± 34	ND	3.7	0.58	1	12	14	29	ND	8.3	0.11	ND	ND	20
RI Project Screening Goal				100/200 (a)		9.96	16.1		20		2	100	2,960	250		1,600	400			24,000
ARAR			8,000,000 (b)							0.233 (c)								400 (b)	5.6 (b)	
Regional Background (d)									7.3	0.61	0.77	48.15	36.36	16.83		38.19	0.78	0.61	NA	85.06

PA/SI = Preliminary Assessment/Site Inspection
RI = Remedial Investigation
USEPA = United States Environmental Protection Agency
ft-bgs = Feet below ground surface
µg/kg = Micrograms per kilogram
mg/kg = Milligrams per kilogram
pCi/g = picoCuries per gram
WTPH-D,G = Washington Total Petroleum Hydrocarbons - diesel, gasoline
ND = Not detected above method reporting limit
NA = Not available
ARAR = Applicable or Relevant and Appropriate Requirement for compounds detected during the PA/SI that were not detected during the RI.
(a) = Project Screening Goal for TPH-gasoline = 100 mg/kg; Project Screening Goal for TPH-diesel = 200 mg/kg.
(b) = Model Toxics Control Act Method B Non-Cancer Formula Value.
(c) = Model Toxics Control Act Method B Cancer Formula Value.
(d) = 90th percentile value for the Puget Sound Region (As, Be, Cd, Cr, Cu, Pb, Ni, and Zn) or Washington State (Se and Ag) (Washington State Department of Ecology, 1994a).
* = These values were based on analysis for total petroleum hydrocarbons by EPA Method 418.1. The WTPH-D,G analyses yielded ND results.
Shaded cells indicate a detection above the associated RI Project Screening Goal or ARAR.

Constituent Abbreviations

Sb = Antimony	Cu = Copper	Tl = Thallium
As = Arsenic	Hg = Mercury	Pb = Lead
Be = Beryllium	Ni = Nickel	Zn = Zinc
Cd = Cadmium	Se = Selenium	
Cr = Chromium	Ag = Silver	

TABLE 2-2

Summary of PA/SI Groundwater Chemical Quality Data
143rd CCSQ, Seattle ANGS, Seattle, Washington
Source: Optech, 1995

Location	Volatile Organic Compounds (USEPA Method 8240) (µg/l)	Semivolatile Organic Compounds (USEPA Method 8270) (µg/l)	Total Petroleum Hydrocarbons (WTPH-D) (µg/l)	Polychlorinated Biphenyls (USEPA Method 8080) (µg/l)	Radionuclides (USEPA Method 9310) (pCi/l)		Trace Metals (µg/l)													
					Gross Alpha	Gross Beta	Sb	As	Be	Cd	Cr	Cu	Pb	Hg	Ni	Ag	Se	Tl	Zn
Background (BS-004PZ)	ND	ND	ND	ND	**36 ± 42**	**78 ± 25**	ND	**38**	**13**	0.6	**120**	290	**33**	ND	**160**	ND	ND	**5.7**	450
BS-005PZ	ND	ND	ND	ND	15 ± 39	**77 ± 24**	ND	**28**	**540**	ND	5.2	54	**22**	ND	31	ND	2	ND	ND
BS-006PZ	ND	ND	ND	ND	**59 ± 59**	**58 ± 30**	ND	**27**	**820**	ND	**97**	78	**26**	ND	60	ND	3.1	ND	ND
RI Project Screening Goal					15	11.3		5				1,000			100				5,000
ARAR									4 (a)	5 (a,b)	50 (b)		5 (b)				50 (a)	2 (a)	

PA/SI = Preliminary Assessment/Site Inspection
RI = Remedial Investigation
USEPA = United States Environmental Protection Agency
µg/l = Micrograms per liter
pCi/l = picoCuries per liter
WTPH-D = Washington Total Petroleum Hydrocarbons - diesel
ND = Not detected above method reporting limit
ARAR = Applicable or Relevant and Appropriate Requirement for compounds detected during the PA/SI that were not detected during the RI.
(a) = Federal Primary Maximum Contaminant Level (MCL)
(b) = Model Toxics Control Act Method A Table Value
Shaded cells indicate a detection above the associated RI Project Screening Goal or ARAR.

Constituent Abbreviations

Sb = Antimony
As = Arsenic
Be = Beryllium
Cd = Cadmium
Cr = Chromium
Cu = Copper
Pb = Lead
Hg = Mercury
Ni = Nickel
Se = Selenium
Ag = Silver
Tl = Thallium
Zn = Zinc

2.4.2.8 Conclusions and Recommendations of the PA/SI Report

The PA/SI report recommended that further investigation be performed at the IRP site to determine the source and areal extent of TPH detected in soil samples collected from soil boring BS-003BH and the gross alpha and gross beta radiation detected in soil and groundwater samples. The PA/SI report also noted that State or Federal standards were exceeded for several trace metals, but concentrations of those metals did not exceed site-specific background concentrations except for beryllium in groundwater.

2.5 Review of PA/SI Trace Metal Data

During development of the RI/FS Work Plan, the PA/SI soil and groundwater data were reviewed to determine whether the trace metals detected during the PA/SI represent background concentrations or possible impacts from site activities. The results of the data review are presented below.

2.5.1 Soil Data

Nine soil samples collected at the IRP site and one soil sample collected at a background location during the PA/SI yielded detectable concentrations of arsenic, beryllium, cadmium, chromium, copper, lead, nickel, and zinc. The beryllium concentrations detected in the soil samples exceeded the MTCA Method B Cancer Formula Value.

In accordance with WDOE guidance (WDOE, 1992; 1995), metal concentrations detected in the PA/SI soil samples were compared to regional natural background concentrations to determine whether site soils may be contaminated with trace metals. Natural background is defined by the WDOE as the concentration of a hazardous substance that is consistently present in the environment which has not been influenced by human activity.

According to WDOE guidance, the 95 percent upper confidence limit (UCL) mean concentration of a site data set may be compared to the 90th percentile of the regional background data set to evaluate whether site-related concentrations are below natural background concentrations. Site-related concentrations are considered to be below natural background concentrations when the 95 percent UCL mean concentration of the site data set is less than the 90th percentile background concentration and

- No single sample has a concentration greater than two times the 90th percentile value; and
- Less than 10 percent of the sample concentrations exceed the 90th percentile value.

Regional natural background soil metals concentrations have been estimated for the Puget Sound region, where the Seattle ANGS is located (WDOE, 1994a). Comparison of the PA/SI soil data to regional natural background soil metals data (Table 2-1) suggests that contamination above background may exist for arsenic, beryllium, cadmium, copper, and lead. Either more than 10 percent of the sample results for these metals are greater than natural background, or a single concentration value is greater than twice the corresponding background value, or both. However, comparison of regional natural background metals concentrations to site soil sample results may not be appropriate. The PA/SI data suggest that background soil concentrations of beryllium, cadmium, and lead in the vicinity of the Seattle ANGS may be greater than regional natural background values.

Since the comparison of the PA/SI metals data to published natural background soil metals data indicated possible soil contamination related to site activities, further investigation of metals in soil at the IRP site was included in the scope of the RI.

2.5.2 Groundwater Data

Groundwater samples collected during the PA/SI from two monitoring wells located downgradient of the IRP site yielded detectable concentrations of arsenic, beryllium, chromium, copper, lead, nickel, and selenium. Of these metals, arsenic, beryllium, chromium, and lead exceeded regulatory criteria (Table 2-2). However, the PA/SI groundwater samples were not filtered prior to analysis. Consequently, the reported values for metals in groundwater may include metals that were present in sediments contained in the samples. An accurate determination of dissolved metal concentrations in groundwater requires the collection and analysis of filtered samples.

According to MTCA (Washington Administrative Code [WAC] 173-340-720[8][a]), the WDOE will generally accept filtering of groundwater samples for inorganic substances where: (a) a properly constructed monitoring well cannot be sufficiently developed to provide low-turbidity water samples; (b) due to natural background concentrations of hazardous substances in the aquifer material, unfiltered samples would not provide a representative measure of groundwater quality; and (c) filtering is performed in the field with all practicable measures taken to avoid exposing the groundwater samples to the ambient air prior to filtering.

Conditions (a) and (b) above are satisfied for the Seattle ANGS. Accordingly, groundwater samples collected during the RI were filtered in accordance with condition (c) to determine dissolved metal concentrations.

SECTION 3.0

ENVIRONMENTAL SETTING

This section describes the environmental setting at the Seattle ANGS to establish a reference for describing the work performed during the RI.

3.1 Topography

The Seattle ANGS is in King County in the Puget Sound Lowlands physiographic province. The Puget Sound Lowlands is a north-south trending structural and topographic depression bordered on the west side by the Olympic Mountains and on the east by the Cascade Range. The Lowlands extend north from the Oregon-Washington State line to the Canadian border (OpTech, 1995).

The Seattle ANGS is located on flat terrain with a surface elevation of approximately 7 feet above mean sea level.

3.2 Meteorology

The climate in the Seattle area is characterized by mild summers and cool winters, with long spring and fall seasons. In winter, the daily temperatures range from 37 degrees Fahrenheit (°F) to 47°F, while in summer the daily temperatures range from 55°F to 72°F. The average annual precipitation is 38.84 inches, including 7.4 inches of snow. The greatest percentage of rainfall occurs in the winter months from November to January. The average monthly precipitation ranges from 0.89 inches in July to 6.29 inches in December. The heaviest 24-hour rainfall of 3.74 inches was recorded on October 5-6, 1981. Rainfall intensity, based on a 2-year, 24-hour duration, is 2.0 inches. Free water surface evaporation in the Seattle area is approximately 25 inches per year, resulting in a net precipitation of 13.84 inches per year. The prevailing wind is from the southwest, and the highest average wind speed of 9.8 miles per hour is experienced during the month of March (OpTech, 1995).

3.3 Geology

The Seattle ANGS is situated in the central portion of the Puget Sound Lowlands, a broad glacial drift plain that is dissected by a network of deep marine embayments. The site is located within the north-south trending Duwamish Valley on the Duwamish Waterway flood plain, a former marine embayment that has been filled with sediment since the end of the last glaciation, referred to locally as the Vashon glaciation. The valley is bounded on the east and west by uplands of glacial drift and bedrock.

Sediments collectively termed as the Vashon drift represent the last major advance and retreat of glacial ice in the Puget Sound area, and commonly overlie a sequence of older glacial and nonglacial sediments throughout the site vicinity. Near the site, at least 75 feet of recent alluvium deposited by the Duwamish River is underlain by Vashon drift deposits.

Alluvial deposits in the Duwamish Valley primarily range from silt through silty sand to fine to medium sand. The alluvial deposits exhibit gradation common to meandering rivers that have resulted in intermittent layering of silts and sands with occasional layers of peat and organic materials deposited in marsh areas.

In the 1910s, much of the Duwamish Valley was raised with fill to accommodate development. The meandering Duwamish River was channelized in its present position during this time. Prior to extensive filling and regrading in the vicinity of Seattle ANGS between 1917 and 1919, a meander of the Duwamish River flowed along the eastern site boundary. Fill materials in the former channel bed in the vicinity of Seattle ANGS consist of up to 6 feet of silty sand to fine sand and over 1.5 to 10 feet of coal ash, clinkers, and brick fragments. Soils below the coal combustion residue consist of fine sand with a trace of gravel to a depth of at least 35 feet (OpTech, 1995).

Figures 3-1 and 3-2 present a geologic map of the Seattle, Washington, area and a generalized stratigraphic column for the Puget Sound area, respectively.

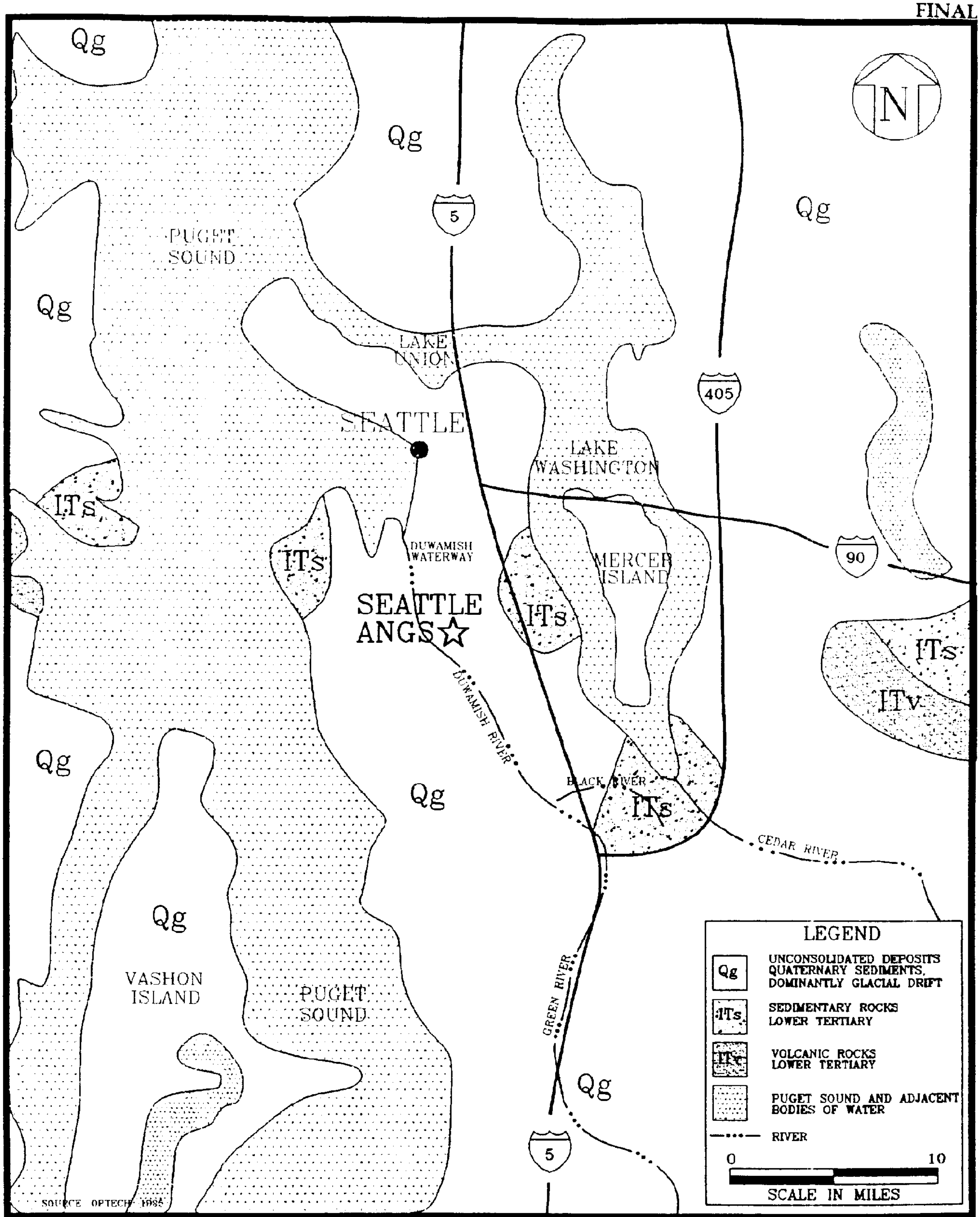

FIGURE 3-1

GEOLOGIC MAP OF THE SEATTLE, WASHINGTON AREA
143rd CCSQ, Seattle ANGS
Seattle, Washington

ERM

60323-01 DWG

EPOCH		SOUTHERN	APPROXIMATE THICKNESS OF SOUTHERN UNITS (FEET)	NORTHERN	AGE (YEARS)
		PUGET LOWLAND			
HOLOCENE		RECENT ALLUVIUM	75		10,000
PLEISTOCENE	LATE			FRASER DRIFT: SUMAS DRIFT	11,000
				FRASER DRIFT: EVERSON GLACIOMARINE DRIFT	13,000
		FRASHER DRIFT: VASHON DRIFT	NA	FRASER DRIFT, VASHON DRIFT: VASHON TILL	
				FRASER DRIFT, VASHON DRIFT: ESPERANCE SAND	
				FRASER DRIFT, VASHON DRIFT: LAWTON CLAY	20,000
		SEDIMENTS OF THE NONGLACIAL OLYMPIA INTERVAL	NA	SEDIMENTS OF THE NONGLACIAL OLYMPIA INTERVAL	28,000
				POSSESSION DRIFT	42,000 90,000
				WHIDBEY FORMATION (INTERGLACIAL)	100,000
				DOUBLE BLUFF DRIFT	250,000
		SALMON SPRINGS DRIFT: UPPER SALMON SPRINGS GRAVEL AND TILL	NA		
		SALMON SPRINGS DRIFT: SILT, PEAT AND ASH	NA		1,000,000
		SALMON SPRINGS DRIFT: LOWER SALMON SPRINGS GRAVEL AND TILL	NA		
	EARLY	PUYALLUP FORMATION (INTERGLACIAL)	130		
		STUCK DRIFT	NA		
		ALDERTON FORMATION (INTERGLACIAL)	25		
		ORTING DRIFT	200		2,000,000(?)

NA — NOT AVAILABLE

SOURCE: OPTECH 1995

FIGURE 3-2

GENERALIZED STRATIGRAPHIC COLUMN FOR THE PUGET SOUND LOWLANDS
143rd CCSQ, Seattle ANGS
Seattle, Washington

ERM

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3.4 Soils

The United States Department of Agriculture classified the soil underlying Seattle ANGS as unclassified urban land. Urban land is soil that has been modified by the disturbance of the natural layers with additions of fill material several feet thick to accommodate large industrial and housing installations. In the Duwamish River Valley, the fill ranges from about 3 to more than 12 feet thick, and from gravelly, sandy loam to gravelly loam in texture. The erosion hazard is slight to moderate (OpTech, 1995).

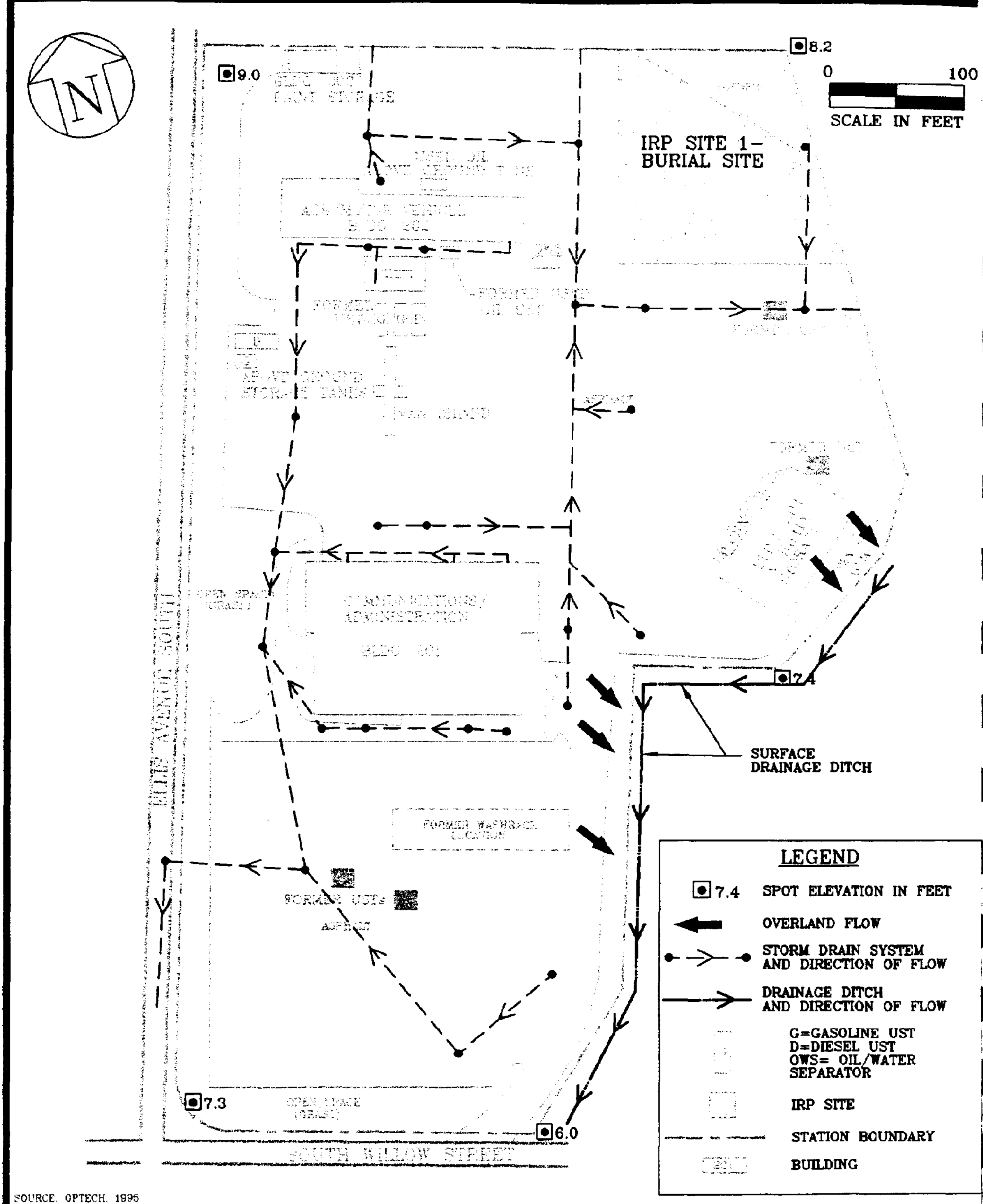
Five Dutch cone penetrometer samples and two borings were drilled by Hart Crowser and Associates, Inc., during soil studies conducted in 1974 and 1982 at Seattle ANGS. Sandy silt to silty sand was the most common sediment within the uppermost 10 feet of unconsolidated sediments. Sand, with occasional thin silty layers, was the predominant lithology encountered from a depth of 10 to 50 feet bgs (OpTech, 1995).

3.5 Surface Water Hydrology

The Seattle ANGS is located approximately one-quarter mile from the main channel of the Duwamish Waterway, a major surface water drainage basin for western Washington. Between 1917 and 1919, the meanders of the Duwamish River were filled in and the Duwamish Waterway was constructed. The western end of the meander near Boeing North Field was not filled and became the present day Slip No. 4.

The Federal Emergency Management Agency reported the drainage basin of the Duwamish as 450 square miles. The Waterway is comprised of the Duwamish River and the Green River. Approximately 5.5 miles downstream of the Station, the Duwamish discharges into Elliot Bay on the Puget Sound.

The Seattle Water Department indicated that the Duwamish Waterway is not used for drinking water and is the only fresh water downgradient of the Station. Surface water drainage is totally controlled by man-made drainage systems that are routed into the municipal storm sewer. Figure 3-3 illustrates the storm drain system at the Seattle ANGS (OpTech, 1995).



SOURCE. OPTECH, 1995

FIGURE 3–3

SURFACE WATER DRAINAGE MAP

143rd CCSQ, Seattle ANGS
Seattle, Washington

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3.6 Hydrogeology

This section describes the regional and local hydrogeology in the vicinity of the Seattle ANGS.

3.6.1 Regional Hydrogeology

Groundwater in the Duwamish River Valley exists in two lithostratigraphic units. Shallow groundwater is present within a river alluvium unit. This unit is found underlying the Seattle ANGS and is described in the following section. Deeper groundwater reportedly exists beneath the river alluvium unit in unconsolidated glacial deposits (Luzier, 1969). Characteristics of this deeper aquifer are unknown; groundwater probably flows toward the Duwamish River and thus to Elliot Bay within the deeper aquifer (OpTech, 1995).

The City of Seattle Water Department has no municipal wells within 4 miles of the Station, and records obtained from WDOE indicate that no private drinking water wells are within a 1-mile radius of the Station. The surrounding population reportedly obtains drinking water from municipal water (OpTech, 1995).

The EDR environmental database report prepared as part of the RI/FS Work Plan presents data regarding water supply wells in the USEPA's database and wells included in the United States Geological Survey's database. All of the wells identified in the EDR report were greater than 1 mile from the Seattle ANGS (ERM, 1996).

The PA/SI report identified wells located within a 4-mile radius of the Seattle ANGS. The wells were identified based on a review of State records. Construction details, use, and ownership information for the wells identified during the PA/SI are summarized in OpTech (1995).

3.6.2 Local Hydrogeology

Unconfined groundwater occurs at shallow depths in the vicinity of the Seattle ANGS within the upper part of the recent river alluvium. Previous investigations in the area have found that groundwater is influenced by seasonal precipitation and tidal fluctuations (OpTech, 1995).

Groundwater was encountered at the Seattle ANGS at a depth of approximately 11 feet bgs in October 1974 and 5 feet bgs in January 1982 during geotechnical investigations conducted by Hart Crowser and Associates, Inc. These measurements reflect water levels during the dry and wet seasons in the region, respectively. Several investigations undertaken on behalf of Boeing at Boeing North Field have encountered groundwater at similar depths. Groundwater on the valley floor is generally encountered at depths between 4 and 11 feet bgs. Groundwater flow in the vicinity of the Seattle ANGS is generally to the west, southwest, and south toward the Duwamish Waterway, at a gradient of approximately 0.002 feet per foot (OpTech, 1995).

3.7 Critical Habitats and Endangered or Threatened Species

No critical habitats or endangered or threatened species have been identified within 4 miles of the Seattle ANGS (OpTech, 1995).

SECTION 4.0

FIELD PROGRAM

4.1 Summary

This section summarizes the elements of the RI field program. Deviations from the RI/FS Work Plan, data validation, and disposition of investigation derived wastes are also described. The results of the RI field investigation are presented and discussed in Section 5.0.

The RI included a focused investigation of the IRP site, as well as a general sitewide investigation. Memoranda for field activities are included in Appendix A. The field investigation consisted of the following activities:

- A Geoprobe/HydroPunch groundwater investigation;
- Collection of surface and subsurface soil samples for field-screening and laboratory analysis;
- Collection of storm sewer catch basin samples for laboratory analysis;
- Installation of groundwater monitoring wells and quarterly groundwater sampling for laboratory analysis;
- Slug testing to estimate the hydraulic conductivity of the shallow groundwater aquifer; and
- A location and elevation survey of the RI sampling locations.

4.2 Deviations from the Work Plan

Two deviations from the RI/FS Work Plan occurred during field activities. The first deviation was the relocation, by approximately 200 feet to the southeast, of the proposed site for monitoring well MW-3 due to the results of the Geoprobe/HydroPunch investigation. The second deviation was postponement of the 30-day post monitoring well installation groundwater sampling event until approximately 60 days after installation of the monitoring wells.

4.3 Field-Screening Activities

This section describes field-screening activities conducted during the RI. Field-screening was used in conjunction with visual observations to support field decisions regarding sample selection for laboratory analysis and optional additional sampling activities.

4.3.1 Organic Vapor Screening

Soil samples collected during the RI were screened for the presence of organic vapors using a photoionization detector (PID). A portion of each soil sample was placed in a resealable plastic bag and allowed to equilibrate at ambient temperature for at least 15 minutes. The organic vapor concentration of the sample was then measured by carefully opening the bag and immediately inserting the PID probe into the headspace above the sample. The maximum PID reading observed for each sample was recorded on soil sampling field forms and/or borehole logs.

4.3.2 Petroleum Hydrocarbon Screening

In addition to organic vapors, soil samples collected during the RI were also field-screened for TPH using an immunoassay test kit (USEPA Method 4030). Soil samples screened for TPH were extracted in the field using reagent grade methanol. The sample extract was then placed in a test tube containing antibodies, substrates, and enzymes. A chemical reaction occurred in the test tube that was stopped after a specific time period by adding a dilute acid. The color of the material in the test tube was then compared to a sensitivity standard to measure the quantity of TPH in the soil sample.

The immunoassay test kit allows screening for the presence of petroleum hydrocarbons at specified detection limits within two sensitivity ranges, depending on the sample volume used for the analysis. The detection limits used during the RI were 15 milligrams per kilogram (mg/kg) and 100 mg/kg.

4.4 Confirmation Activities

This section describes the confirmation activities performed during the RI. Table 4-1 summarizes the scope of the RI soil and groundwater sampling.

4.4.1 Geoprobe/HydroPunch Groundwater Sampling

Twenty-two Geoprobe/HydroPunch groundwater samples were collected during RI field activities (Figure 4-1). The purpose of the Geoprobe/HydroPunch groundwater sampling was to:

- Provide a more widespread distribution of groundwater sampling points at locations downgradient of the IRP site;
- Provide additional groundwater data in order to assess the potential for on-Station transport of VOCs and TPH from upgradient sources; and
- Provide additional data regarding subsurface lithology.

The Geoprobe/HydroPunch groundwater samples were analyzed in the field using a mobile laboratory. In addition, soil samples collected from four of the Geoprobe/HydroPunch locations were used for lithologic logging.

4.4.2 Surface Soil Sampling

Ten surface soil samples (SS-1 through SS-10) were collected during RI field activities (Figure 4-2). Per ANG site investigation protocol, surface soil is usually referred to as the soil extending from the surface to a depth of no more than 1 foot. The surface soil samples were collected from approximately 0.5 feet bgs.

The primary purpose of the surface soil samples was to assess the potential on-Station transport of TPH and radionuclides from off-site locations. The secondary purpose stated in the RI/FS Work Plan was to evaluate the potential for on-site transport of SVOCs and VOCs. However, as discussed in Section 5.0, surface soil samples were not analyzed for VOCs or SVOCs because field-screening results indicated that these compounds were likely not present in the samples.

TABLE 4-1

Remedial Investigation Soil and Groundwater Sampling
143rd CCSQ, Seattle ANGS, Seattle, Washington

Site	Matrix	Sampling Method	Field Parameters	Lab Parameters	USEPA Method	Original Samples	QA/QC Samples					Matrix Total*
							Trip Blank	Rinsate Blank	Field Blank	Field Duplicate	MS/MSD	
Background	Subsurface Soil 3 Sites	Soil Borings	Soil headspace screening using PID/field TPH Soil Classification	PP Metals	3050/6010/6020/7470	9		1		1		10
				SVOCs	3550/8270	9		1		1		10
				TPH	WTPH-HCID (1)	9		1		1		10
				Radionuclides	SM-7110A/B, 903.1, 904.0	9		1		1		10
	Groundwater 1 RI MW 1 PA/SI MW	Monitoring Wells (per round)	Temperature pH Specific conductance Turbidity	PP Metals	6010/6020/7470	2						2
				VOCs	5030/8260	2	1					2
				SVOCs	3550/8270	2						2
				TPH	WTPH-HCID (1)	2						2
				Radionuclides	SM-7110A/B, 903.1, 904.0	2						2
IRP Site No.1	Subsurface Soil 8 Sites	Soil Borings	Soil headspace screening using PID/field TPH Soil Classification	PP Metals	3050/6010/6020/7470	16		1	1	1	2	19
				TPH	WTPH-HCID (1)	16		1	1	1	2	19
				SVOCs	3550/8270	16		1	1	1	2	19
				Radionuclides	SM-7110A/B, 903.1, 904.0	16		1	1	1	2	19
	Storm Sewer Catch Basin 2 Sites	Grab Samples	Soil headspace screening using PID/field TPH	PP Metals	3050/6010/6020/7470	2						2
				TPH	WTPH-HCID (1)	2						2
				SVOCs	3550/8270	2						2
				VOCs	5030/8260	2						2
				Radionuclides	SM-7110A/B, 903.1, 904.0	2						2

FINAL

TABLE 4-1

Remedial Investigation Soil and Groundwater Sampling
143rd CCSQ, Seattle ANGS, Seattle, Washington

Site	Matrix	Sampling Method	Field Parameters	Lab Parameters	USEPA Method	Original Samples	QA/QC Samples					Matrix Total*
							Trip Blank	Rinsate Blank	Field Blank	Field Duplicate	MS/MSD	
IRP Site No. 1 (cont.)	Surface Soil	Surface Sampling	Soil headspace screening using PID/field TPH	TPH	WTPH-HCID (1) WTPH - G/D/HO (2)	10			1	1	1	12
	10 Sites		Soil classification	Radionuclides	SM-7110A/B, 903.1, 904.0	10			1	1	1	12
	Groundwater	HydroPunch	Temperature pH	Selected VOCs	8010/8020	22				2	1	25
	4 RI MW	(field lab)	Specific conductance	TPH	WTPH-HCID (1)	22				2	1	25
	2 PA/SI MW	Monitoring Wells (per round)	Temperature	PP Metals	6010/6020/7470	6		1	1	1	1	8
			pH	VOCs	5030/8260	6	1	1	1	1	1	8
			Specific conductance	SVOCs	3550/8270	6		1	1	1	1	8
				TPH	WTPH-HCID (1)	6		1	1	1	1	8
			Turbidity	Radionuclides	SM-7110A/B, 903.1, 904.0	6		1	1	1	1	8

VOCs = Volatile organic compounds
SVOCs = Semivolatile organic compounds
PP Metals = Priority Pollutant metals
TPH = Total petroleum hydrocarbons
QA/QC = Quality assurance/quality control
MS/MSD = Matrix spike/matrix spike duplicate
USEPA = United States Environmental Protection Agency
PID = Photoionization detector
RI = Remedial Investigation
PA/SI = Preliminary Assessment/Site Inspection
MW = Monitoring Well
* = Blank samples not included in matrix total
(1) = State of Washington TPH analysis - hydrocarbon screening/identification method
(2) = State of Washington TPH analysis - gasoline/diesel/heavy oil quantification method

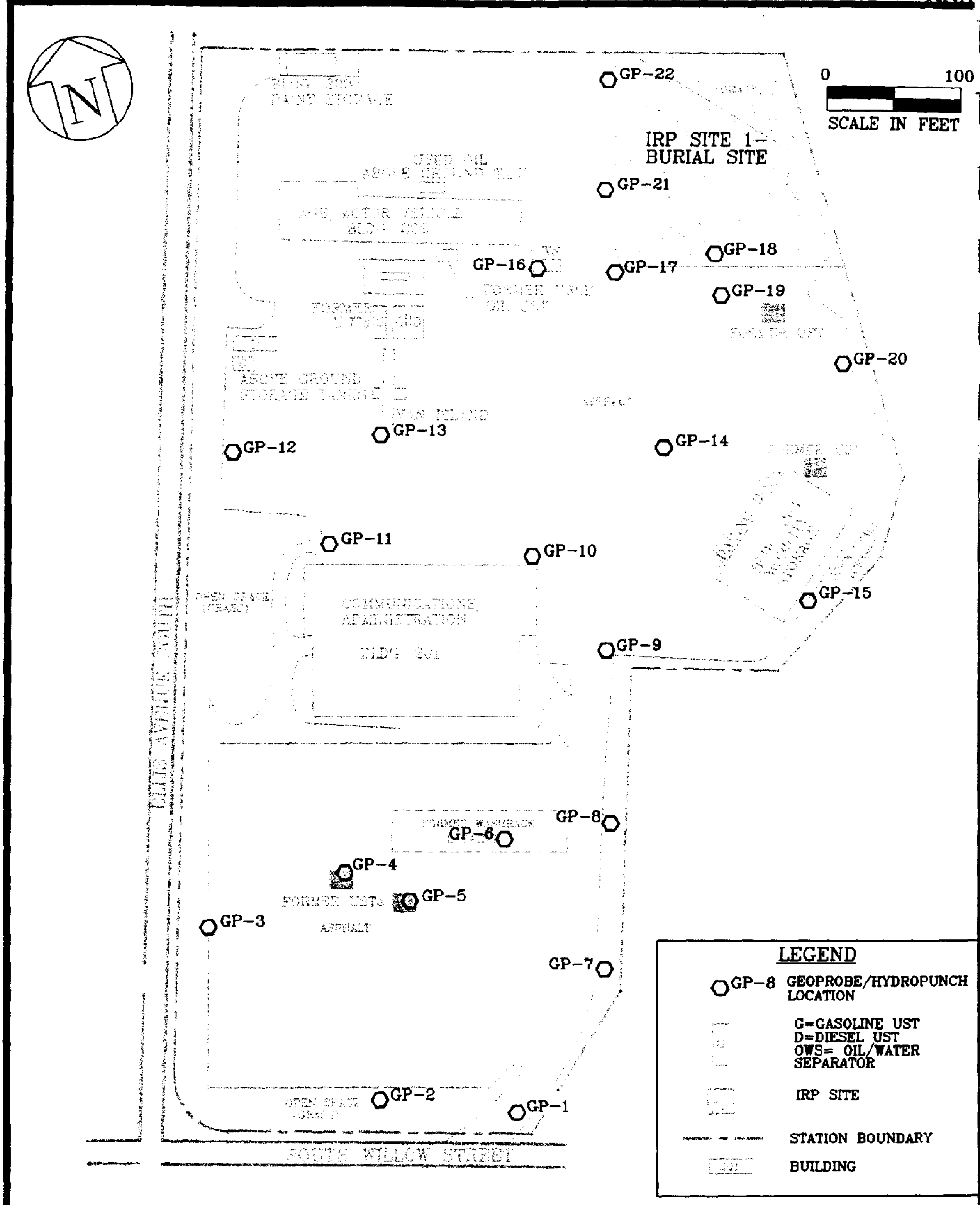

FIGURE 4-1

60324-01.DWG

GEOPROBE/HYDROPUNCH
GROUNDWATER SAMPLING LOCATIONS
143rd CCSQ, Seattle ANGS
Seattle, Washington

ERM

KCSlip4 40652

SEA407182

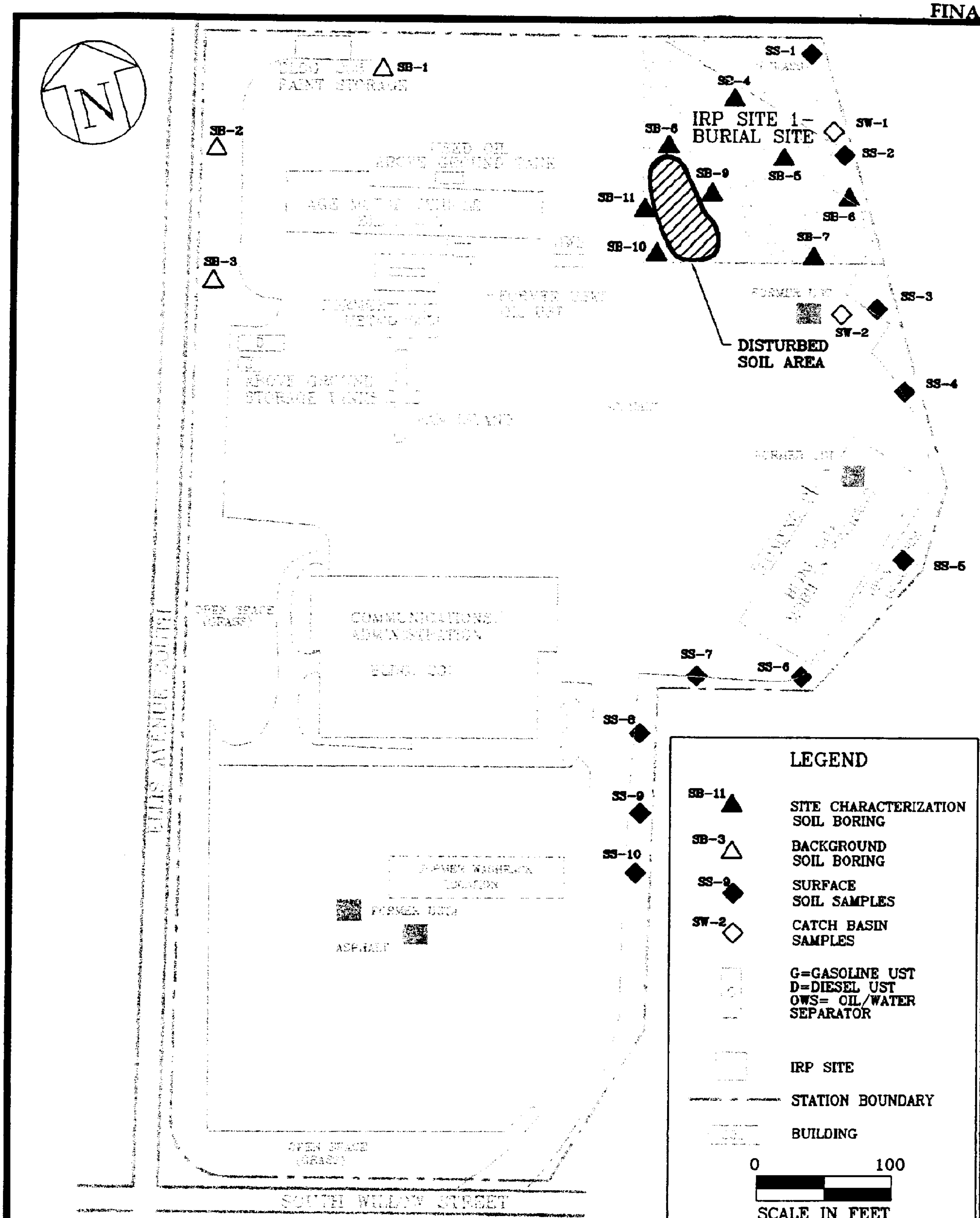

FIGURE 4-2

80324-02 DWG

SOIL AND STORM SEWER
CATCH BASIN SAMPLING LOCATIONS
143rd CCSQ, Seattle ANGS
Seattle, Washington

ERM

4.4.3 Storm Sewer Catch Basin Sampling

Two samples were collected from storm sewer catch basins within or near the IRP site (samples SW-1 and SW-2; Figure 4-2). The samples were collected for the purpose of assessing potential off-site migration of contaminants via erosion and transport of sediments through the existing storm sewer system. The catch basin samples consisted of a mixture of sediment and water.

4.4.4 Subsurface Soil Sampling

A total of 11 soil borings (SB-1 through SB-11) were drilled for collection of subsurface soil samples (Figure 4-2). Borings SB-1 through SB-3 were drilled in background locations to evaluate site-specific background concentrations of target compounds. Borings SB-4 through SB-11 were drilled to characterize the lateral and vertical distribution of target compounds in soil at the IRP site. Four of the eight site-characterization borings were located on the perimeter of the area identified during the PA/SI geophysical survey as a "disturbed soil" area. Borehole logs for the RI soil borings are included in Appendix B.

4.4.5 Monitoring Well Installation

Five groundwater monitoring wells were installed during the RI (Figure 4-3). Four monitoring wells (MW-2 through MW-5) were for the purpose of defining the extent of groundwater contamination downgradient of the IRP site, and general groundwater quality at the Seattle ANGS. One monitoring well (MW-1) was for the purpose of further defining site-specific background groundwater quality at the Station. Table 4-2 provides construction information for both the PA/SI and RI monitoring wells. Borehole logs and well construction diagrams for the RI monitoring wells are included in Appendix B.

4.4.6 Aquifer Testing

Six slug tests were performed at downgradient monitoring well MW-3 (Figure 4-3) to estimate the hydraulic conductivity of the shallow unconfined aquifer at the Seattle ANGS.

TABLE 4-2

Monitoring Well Installation Summary
143rd CCSQ, Seattle ANGS, Seattle, Washington

Location	IRP Investigation	Date Completed	Measuring Point Elevation (ft-amsl)	Total Depth (ft-bgs)	Casing Diameter/ Material	Wellhead Completion	Screen Slot Size (inches)	Annular Seal	Screened Interval (ft-bgs)	Top of Sand Filter Pack (ft-bgs)
BS004PZ (Background)	PA/SI	7/14/94	14.66	20.5	2-inch PVC	Flush	0.010	5-feet BC	9.0 - 19.0	7
MW-1 (Background)	RI	10/16/96	14.92	20.5	2-inch PVC	Flush	0.010	2-feet BC	10.0-20.0	7.5
BS005PZ	PA/SI	7/14/94	14.39	20.5	2-inch PVC	Flush	0.010	5-feet BC	9.0 - 19.0	7
BS006PZ	PA/SI	7/14/94	14.59	20.5	2-inch PVC	Flush	0.010	5-feet BC	9.0 - 19.0	7
MW-2	RI	10/16/96	14.60	20.5	2-inch PVC	Flush	0.010	2-feet BC	10.0-20.0	7.5
MW-3	RI	10/17/96	12.50*	20.5	2-inch PVC	Flush	0.010	2-feet BC	10.0-20.0	7.5
MW-4	RI	10/17/96	12.05	20.5	2-inch PVC	Flush	0.010	2-feet BC	10.0-20.0	7.5
MW-5	RI	10/17/96	13.94	20.5	2-inch PVC	Flush	0.010	2-feet BC	10.0-20.0	7.5

(ft-amsl) = Feet above mean sea level

(ft-bgs) = Feet below ground surface

RI = Remedial Investigation

PA/SI = Preliminary Assessment/Site Inspection

BC = Bentonite Chips

* = Suspected error in survey data

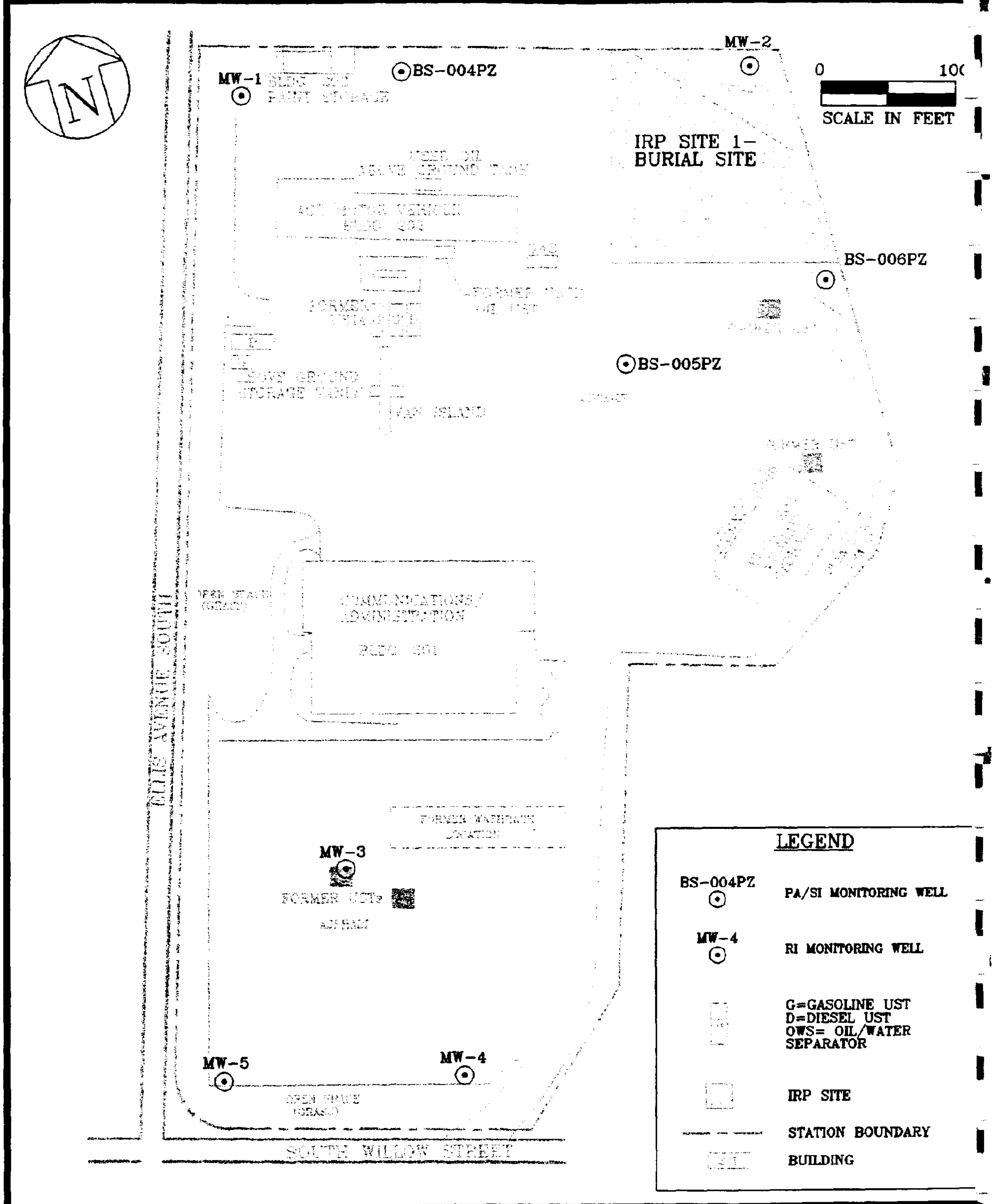

FIGURE 4-3

MONITORING WELL LOCATIONS

143rd CCSQ, Seattle ANGS
Seattle, Washington

ERM

60324-03 DWG

4.4.7 Monitoring Well Groundwater Sampling

Monitoring wells installed previously during the PA/SI (BS-004PZ through BS-006PZ) were sampled during four quarterly groundwater sampling rounds. The first round was conducted on September 17, 1996 prior to the start of RI field work so that laboratory analyses could be completed and reviewed prior to mobilization of the driller to the Station. The three remaining quarterly rounds were conducted concurrent with sampling of monitoring wells installed during the RI, on January 14-15, April 9-11, and July 10-11, 1997.

The RI monitoring wells MW-1 through MW-5 were sampled on five occasions: immediately after well development was completed (October 15-18, 1996); approximately eight weeks after well completion (December 17, 1996); and during the remaining three quarterly sampling events in January, April, and July, 1997. Groundwater samples submitted for metals analysis were filtered in the field using disposable 0.45 micron filters.

4.4.8 Analytical Methods

This section describes the analytical methods used to analyze the samples collected during RI field activities.

4.4.8.1 *Surface Soil Samples*

Surface soil samples were analyzed for TPH using Washington Methods WTPH-HCID (hydrocarbon identification) and WTPH-G, WTPH-D, and WTPH-HO (gasoline, diesel, and heavy oil quantification, respectively), and radionuclides using USEPA Methods 903.1/904.0/SM-7110A/B. Surface soil samples were not analyzed for VOCs or SVOCs because field-screening results indicated that these compounds were likely not present in the samples.

4.4.8.2 *Storm Sewer Catch Basin Samples*

Storm sewer catch basin samples were analyzed for VOCs using USEPA Method 8260, SVOCs using USEPA Method 8270, TPH using Washington Method WTPH-HCID, priority pollutant trace metals using USEPA Methods 6010/6020/7470, and radionuclides using USEPA Methods 903.1/904.0/SM-7110A/B.

4.4.8.3 Subsurface Soil Samples

Subsurface soil samples were analyzed for SVOCs using USEPA Method 8270, TPH using Washington Method WTPH-HCID, priority pollutant trace metals using USEPA Methods 3050/6010/6020/7470, and radionuclides using USEPA Methods 903.1/904.0/SM-7110A/B. Additionally, two soil samples from the soil boring for monitoring well MW-3 were analyzed for VOCs based on a detection of trichloroethene (TCE) in the Geoprobe/HydroPunch groundwater sample collected at this location.

4.4.8.4 Groundwater Samples

Groundwater samples collected during the Geoprobe/HydroPunch investigation were analyzed on site in a mobile field laboratory for VOCs using USEPA Methods 8010 and 8020 and for TPH using Washington Method WTPH-HCID. Groundwater samples collected from monitoring wells were analyzed by an off-site Washington-certified laboratory for VOCs using USEPA Method 8260, SVOCs using USEPA Method 8270, TPH using Washington Method WTPH-HCID, priority pollutant trace metals using USEPA Methods 6010/6020/7470, and radionuclides using USEPA Methods 903.1/904.0/SM-7110A/B. Because the groundwater samples submitted for metals analysis were filtered, the results reported by the laboratory are for dissolved metals.

4.4.9 Field Quality Assurance/Quality Control

This section describes the field quality assurance/quality control (QA/QC) procedures employed during RI field activities at the Seattle ANGS.

4.4.9.1 Field Documentation

Daily log books were kept documenting field activities. Groundwater monitoring information was recorded on groundwater monitoring forms, and well development information was recorded on well development forms. The groundwater monitoring and well development forms were kept in a bound notebook.

4.4.9.2 Equipment Decontamination

Before use, all soil sampling equipment that would directly contact the samples was scrubbed with a solution of tap water and Alconox, and rinsed with tap water, pesticide grade methanol, and American Society for

Testing and Materials (ASTM) Type II reagent-grade water. Auger flights used during drilling activities were decontaminated before each use by steam cleaning. The submersible pump used for purging and sampling monitoring wells was decontaminated by pumping an Alconox solution, followed by tap water and ASTM Type II reagent-grade water, through the pump and tubing.

4.4.9.3 Field QA/QC Samples

Field duplicate samples and field and trip blanks were submitted to the analytical laboratory to provide a means for assessing the quality of the data resulting from the field sampling program. Field blanks were collected at a frequency of one every two days, and trip blanks were collected at a frequency of one per sample cooler per day. Field and trip blank samples were analyzed to check for contamination associated with sampling procedures and/or ambient conditions at the site. Duplicate samples were collected at a frequency of one per ten field samples. Equipment rinsate blanks were collected at a frequency of one every two days to determine the adequacy of the equipment decontamination procedures. Field QA/QC samples were submitted using non-indicative sample identifiers to provide a quality assurance (QA) check on analytical procedures and results.

Matrix spike samples provide information about the effect of the sample matrix on the accuracy of the analytical results. Matrix spike analyses were performed on designated RI samples by the analytical laboratory. All matrix spike analyses were performed in duplicate to assess analytical precision. One matrix spike/matrix spike duplicate sample pair was analyzed for every 20 field samples of a given matrix (groundwater and soil).

Quality control (QC) for field measurements (pH, specific conductance, and turbidity) consisted of an initial instrument calibration and a post-measurement calibration verification using standard reference solutions, in accordance with the manufacturer's recommendations. These procedures were performed at least once per day.

Holding times for water and soil samples are summarized in Table 4-3. Holding times are defined as the maximum length of time that samples may be held before the completion of analytical protocols. All samples except those identified for radionuclide analyses were chilled to a temperature range between 2° and 4° C, and were maintained at that temperature through transport and subsequent storage at the analytical laboratory.

TABLE 4-3

Summary of Holding Times for Water and Soil Samples
143rd CCSQ, Seattle ANGS, Seattle, Washington

Parameter	Holding Time
	Water Samples
VOCs	Analyze within 14 days of collection.
Metals (except Mercury)	Analyze within 6 months of collection.
Mercury	Analyze within 28 days of collection.
TPH	Extract within 14 days of collection and analyze within 40 days of extraction.
SVOCs	Extract within 14 days of collection and analyze within 40 days of extraction.
Radionuclides	Analyze within 6 months of collection.
	Soil Samples
VOCs	Analyze within 14 days of collection.
Metals (except Mercury)	Analyze within 6 months of collection.
Mercury	Analyze within 28 days of collection.
TPH	Extract within 7 days of collection and analyze within 40 days of extraction.
SVOCs	Extract within 14 days of collection and analyze within 40 days of extraction.
Radionuclides	Analyze within 6 months of collection.

4.4.9.4 Soil Sample Preservation

Soil samples submitted for laboratory analysis were contained in stainless steel sleeves. Immediately upon removal from the split-spoon sampler, the ends of the filled sleeves were covered first with a sheet of Teflon (a moisture barrier) and then aluminum foil, and finally with a fitted plastic cap. Samples were then placed in individual resealable plastic bags and stored in a cooler containing enough ice to maintain samples at a temperature of less than 4° C.

4.4.9.5 Groundwater Sample Preservation

Samples collected for VOC analysis were preserved with no more than two drops of a 1:1 solution of hydrochloric acid per 40-milliliter glass VOC vial. The lids of the vials had Teflon-lined septa. Samples collected for TPH analysis were stored in unpreserved 40-milliliter glass VOC vials with Teflon-lined septa. Samples collected for SVOC analysis were stored in unpreserved 1-liter amber glass bottles with Teflon-lined lids. Samples collected for priority pollutant metals analysis were stored in 500-milliliter polyethylene bottles preserved with nitric acid. Samples collected for radionuclide analysis were stored in 1-gallon plastic bottles. All groundwater samples were stored in coolers containing enough ice to maintain samples at a temperature of less than 4° C.

4.5 Analytical Data Review and Validation

The QA effort for this project included a comprehensive review of the laboratory analytical data for conformance with the project data quality objectives specified in the RI/FS Work Plan. In addition, analytical data packages consistent with USEPA Contract Laboratory Program (CLP) reporting requirements were requested for approximately ten percent of the project samples. The analytical data reported in the CLP-like data packages were validated in accordance with *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review* (February 1993) and *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* (February 1994).

The results of the QA analytical data review and validation are summarized in Section 5.0. Appendix J details the scope and results of the data review and validation, and contains the data validation reports for the analytical parameters included in each CLP-like data package.

4.6 Location and Elevation Survey

A location and elevation survey was conducted at the Seattle ANGS by Landmark Incorporated of Bellevue, Washington. The locations of all RI sample points and PA/SI monitoring wells were tied into the State plane coordinate system using an existing United States Geological Survey monument. Appendix C contains the location and elevation data for the Geoprobe/HydroPunch locations, surface soil samples, storm sewer catch basins, soil borings, and monitoring wells surveyed during the RI. The surveyed elevation of monitoring well MW-3 appears to be erroneous based on site characteristics. Accordingly, water level data for this monitoring well were not used on any of the potentiometric surface contour maps presented in Section 5.0.

4.7 Investigation Derived Wastes

Wastes generated during the RI field investigation consisted of soil cuttings from drilling activities, drilling and sampling equipment decontamination water, well development and purge water, and solid wastes (e.g., waste paper, plastic).

Soil cuttings from each soil boring and monitoring well were segregated and contained in labeled, 55-gallon steel drums at the time of drilling. Well development water and purge water was also segregated by well and contained in 55-gallon steel drums. The drums were moved from each boring/well site to a centralized staging area at the Station. Investigation derived wastes were disposed of in accordance with the recommendations provided in Appendix D.

Uncontaminated solid wastes generated during the RI field work were disposed of with regular Station trash.

SECTION 5.0

INVESTIGATION FINDINGS

This section presents the findings of the RI conducted at the Seattle ANGS, including the results of geologic and hydrogeologic investigations and site-specific background and site-characterization sampling activities.

5.1 Geologic and Hydrogeologic Investigation Results

Data collected during the PA/SI and RI suggests that the near surface geology at the Seattle ANGS is predominantly composed of two units. The first unit is a silty sand fill material present to a depth of approximately 8 feet bgs. The fill material is consistent with the descriptions of the material used to raise the Duwamish Valley for development in the 1910s. The second unit consists primarily of poorly graded, fine-grained sand present from approximately 8 feet bgs to the maximum depth of the borings drilled during the PA/SI and RI. Figure 5-1 shows the orientation of geologic cross-sections through the site; the cross-sections referenced on Figure 5-1 are presented on Figures 5-2 and 5-3.

Groundwater at the Station exists in an unconfined aquifer, with the water table encountered between approximately 6 and 10 feet bgs. Table 5-1 provides a summary of water level data collected during the RI. The water level data indicate that groundwater in the shallow aquifer flows to the south. Potentiometric surface maps for water levels measured on different dates are illustrated on Figures 5-4 through 5-9. As shown on Figures 5-4 through 5-9, water levels beneath the Seattle ANGS respond quickly to seasonal precipitation during the wet season; groundwater elevations increased approximately 2 feet between October 1996 and January 1997.

Slug tests were performed on monitoring well MW-3 in order to determine the hydraulic conductivity of the aquifer. Estimates for hydraulic conductivity, computed using the Bouwer and Rice method of

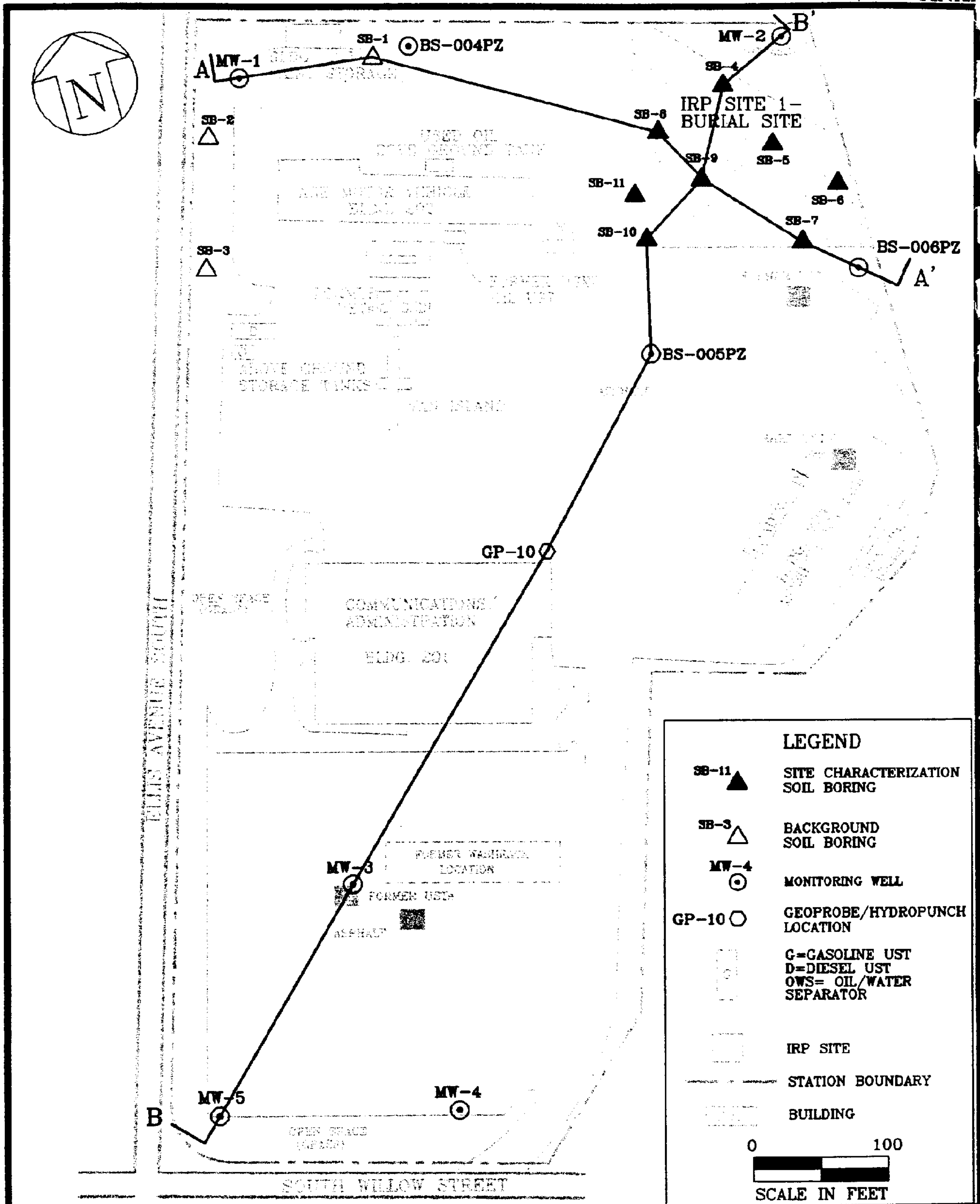

FIGURE 5-1

GEOLOGIC CROSS-SECTION LOCATION MAP
143rd CCSQ, Seattle ANGS
Seattle, Washington

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60325-01 DWG

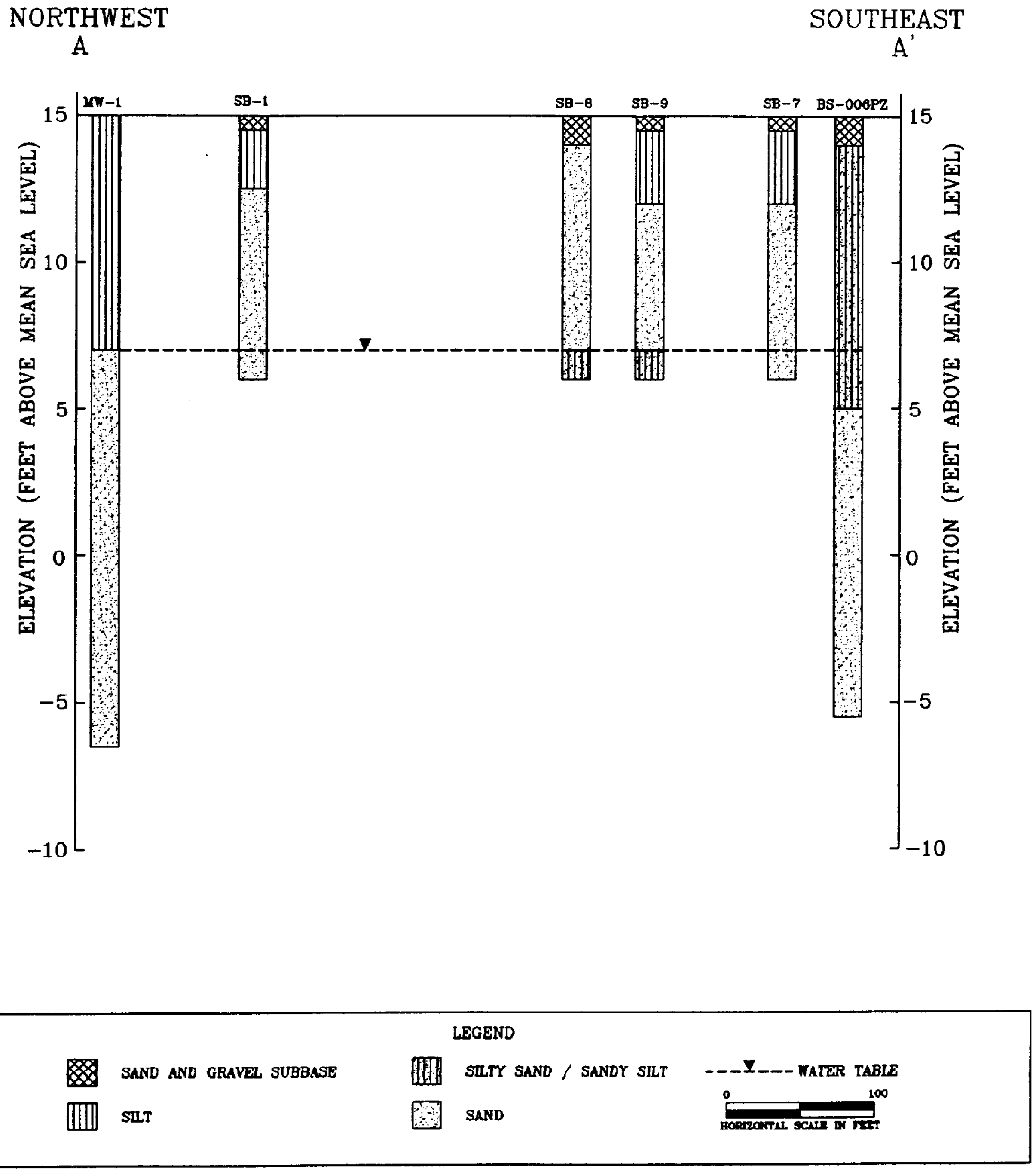

FIGURE 5-2

60325-02 DWG

GEOLOGIC CROSS-SECTION A-A'

143rd CCSQ, Seattle ANGS
Seattle, Washington

ERM

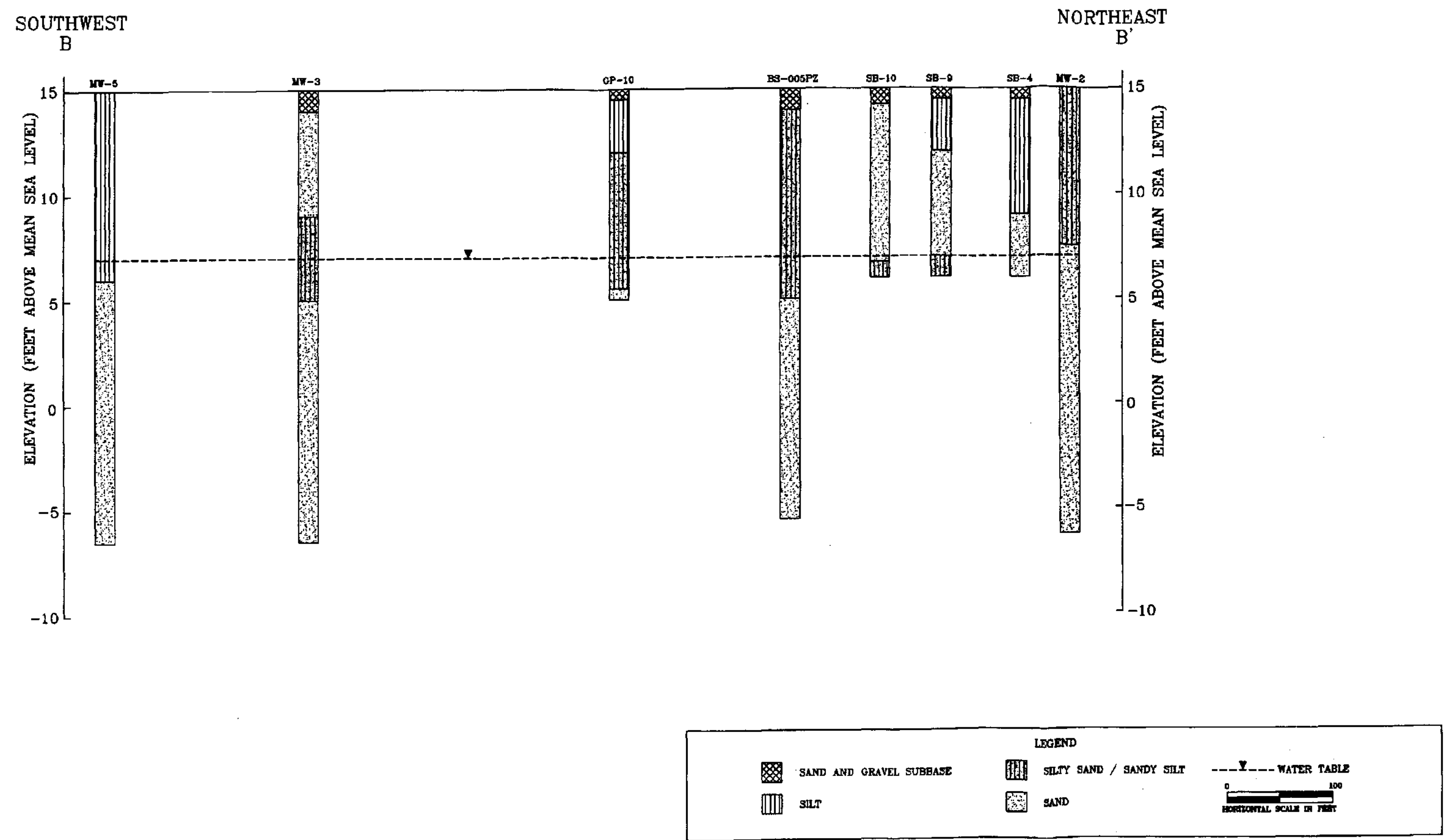

FIGURE 5-3

60325-03.DWG

GEOLOGIC CROSS-SECTION B-B'

143rd CCSQ, Seattle ANGS
Seattle, Washington

ERM

TABLE 5-1

Monitoring Well Water Level Summary
143rd CCSQ, Seattle ANGS, Seattle, Washington

Location	Measuring Point Elevation (ft-amsl)	Date	Depth to Water (ft-bmp)	Water Level Elevation (ft-amsl)
BS-004PZ (Background)	14.66	9/17/96	8.88	5.78
		10/22/96	8.93	5.73
		12/17/96	8.08	6.58
		1/14/97	6.98	7.68
		4/11/97	7.23	7.43
		7/10/97	8.08	6.58
BS-005PZ	14.39	9/17/96	9.16	5.23
		10/22/96	9.42	4.97
		12/17/96	8.51	5.88
		1/15/97	7.48	6.91
		4/10/97	7.65	6.74
		7/11/97	8.47	5.92
BS-006PZ	14.59	9/17/96	9.12	5.47
		10/22/96	9.47	5.12
		12/17/96	8.54	6.05
		1/14/97	7.62	6.97
		4/11/97	7.77	6.82
		7/11/97	8.49	6.10
MW-1 (Background)	14.92	10/22/96	9.18	5.74
		12/17/96	8.20	6.72
		1/14/97	7.11	7.81
		4/10/97	7.58	7.34
		7/11/97	8.51	6.41
MW-2	14.60	10/22/96	8.89	5.71
		12/17/96	8.03	6.57
		1/15/97	7.13	7.47
		4/10/97	7.25	7.35
		7/11/97	7.98	6.62
MW-3	12.50*	10/22/96	7.77	4.73
		12/17/96	6.78	5.72
		1/15/97	7.80	4.70
		4/11/97	6.06	6.44
		7/11/97	6.94	5.56
MW-4	12.05	10/22/96	8.20	3.85
		12/17/96	7.21	4.84
		1/14/97	6.31	5.74
		4/11/97	6.65	5.40
		7/11/97	7.43	4.62
MW-5	13.94	10/22/96	10.06	3.88
		12/17/96	9.06	4.88
		1/14/97	8.01	5.93
		4/11/97	8.36	5.58
		7/10/97	9.23	4.71

(ft-amsl) = Feet above mean sea level
(ft-bmp) = Feet below measuring point
* = Suspected error in survey data

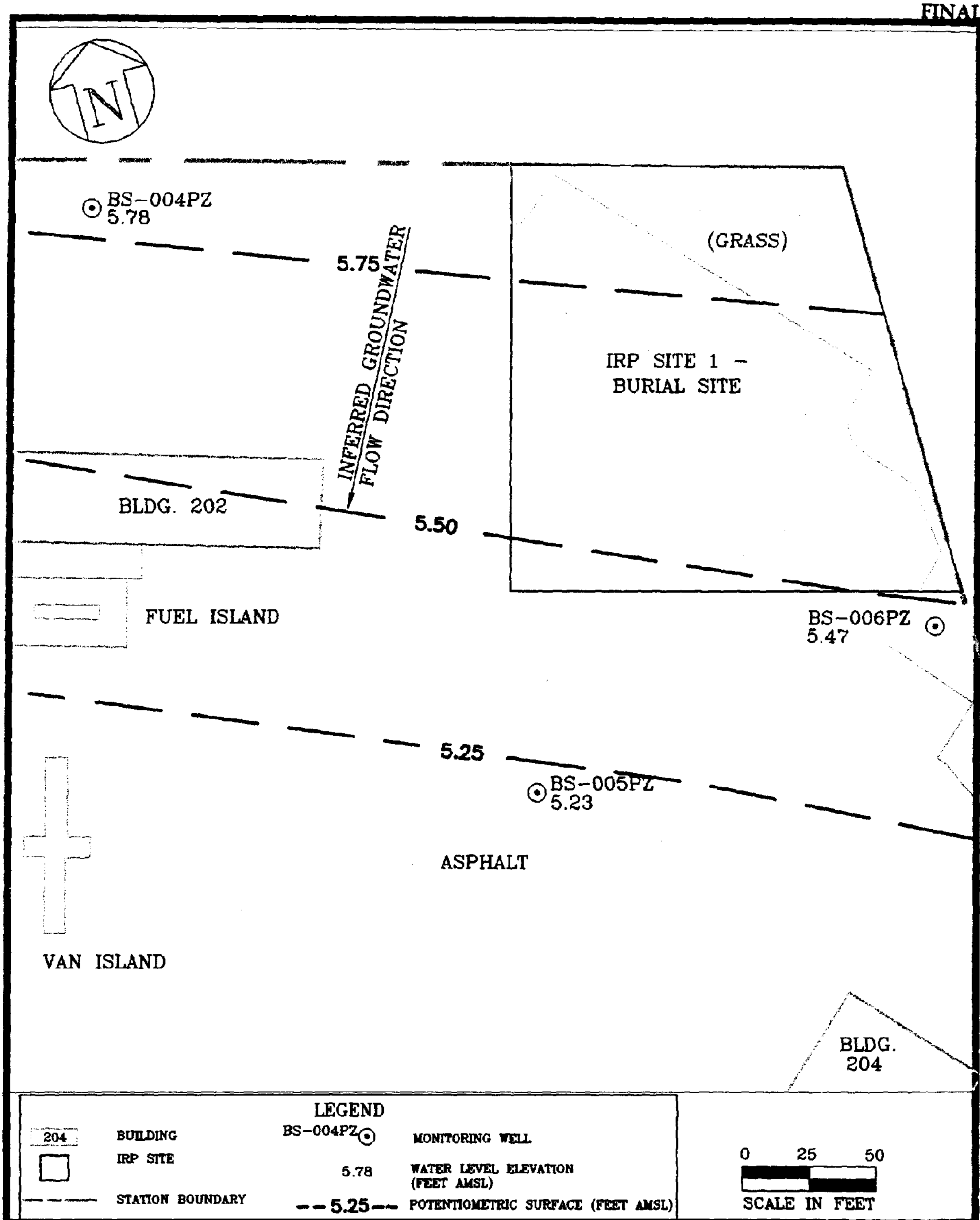

FIGURE 5-4

POTENTIOMETRIC SURFACE
SEPTEMBER 17, 1996

143rd CCSQ, Seattle ANGS
Seattle, Washington

ERM

60325-04.DWG

KCSlip4 40668

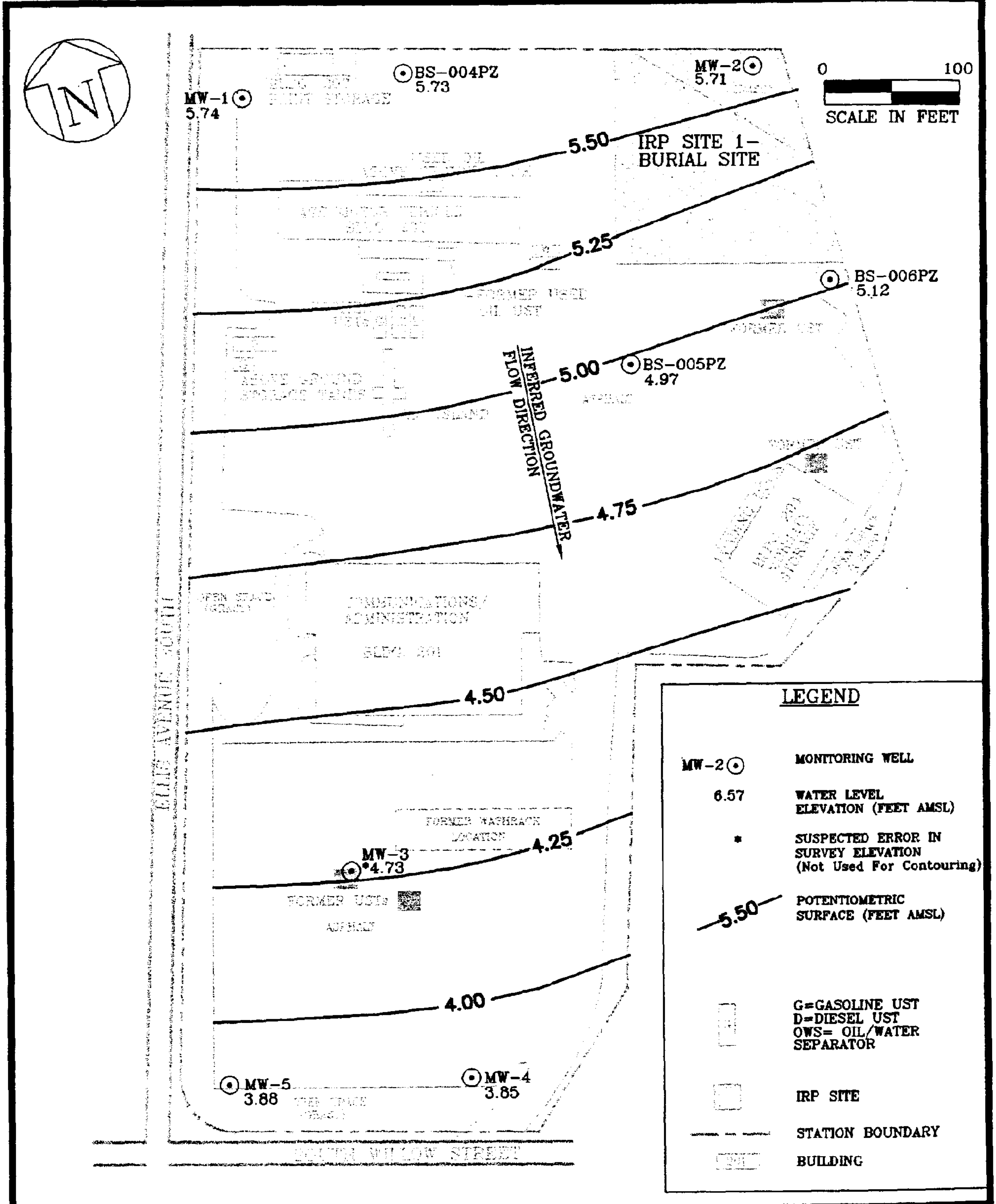

FIGURE 5-5

POTENTIOMETRIC SURFACE
OCTOBER 22, 1996

143rd CCSQ, Seattle ANGS
Seattle, Washington

ERM

60325-05.DWG

KCSlip4 40669

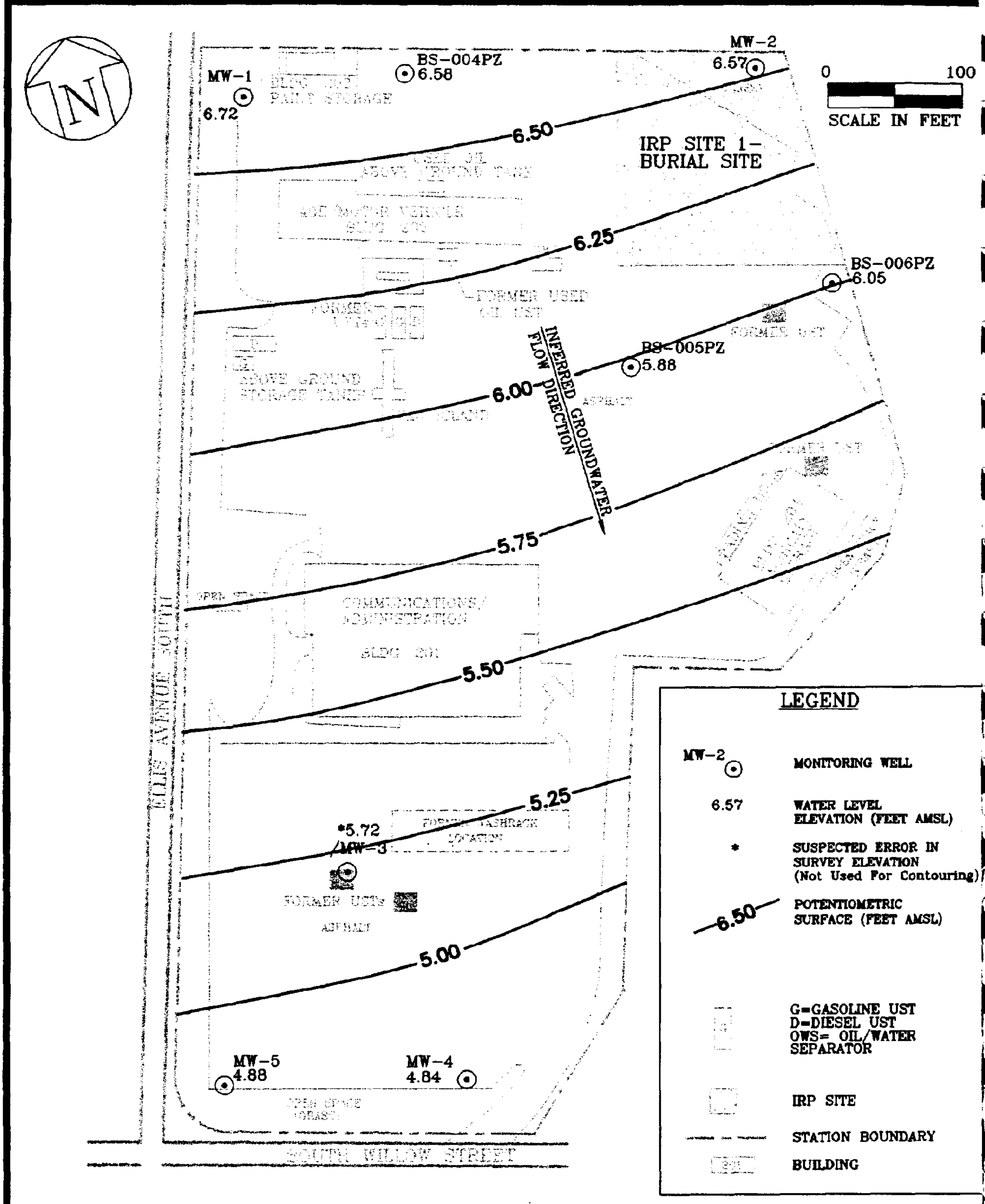

FIGURE 5-6

60325-06 DWC

POTENTIOMETRIC SURFACE
DECEMBER 17, 1996

143rd CCSQ, Seattle ANGS
Seattle, Washington

ERM

KCSlip4 40670

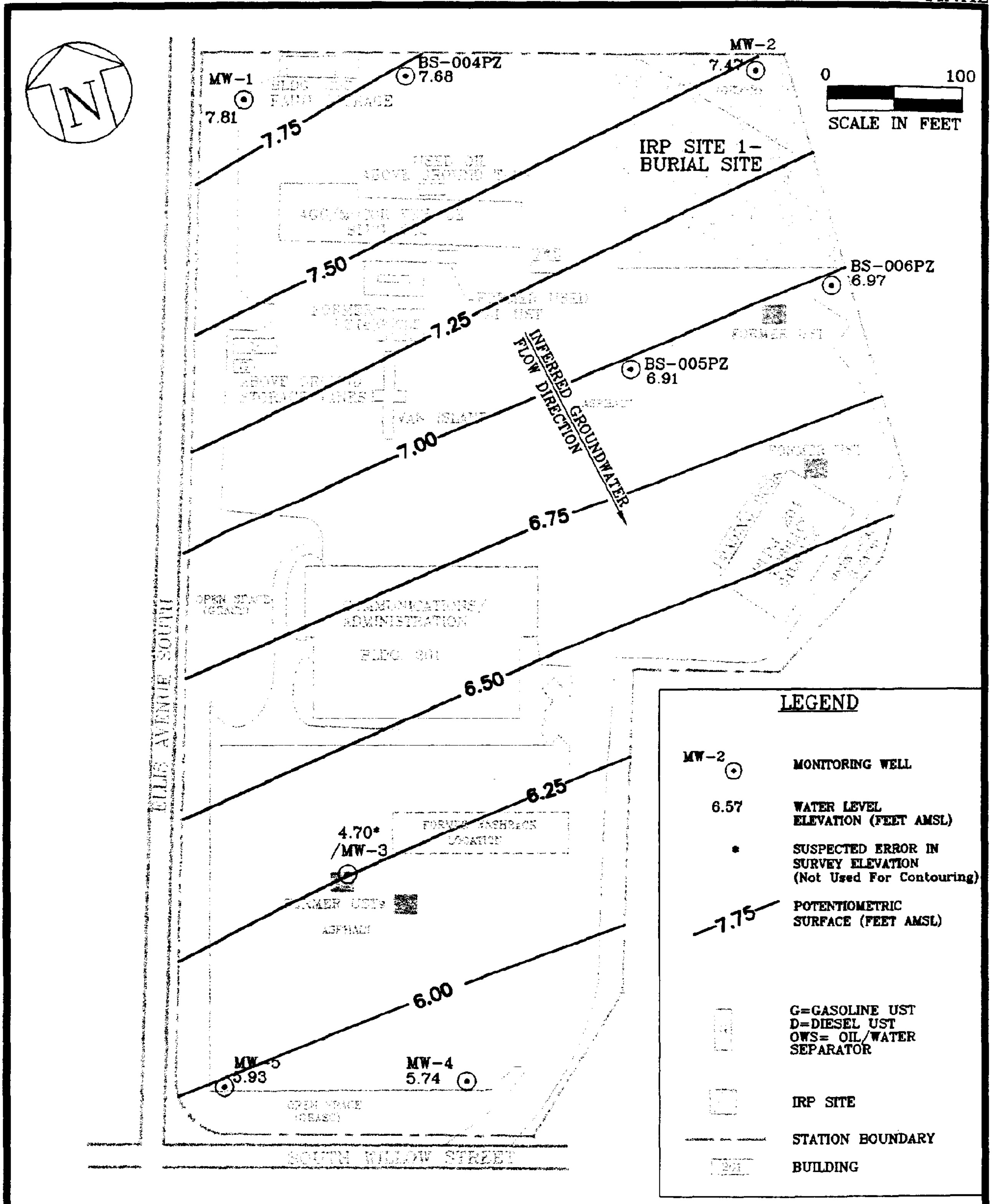

FIGURE 5-7

POTENTIOMETRIC SURFACE
JANUARY 14-15, 1997

143rd CCSQ, Seattle ANGS
Seattle, Washington

ERM

60325-07.DWG

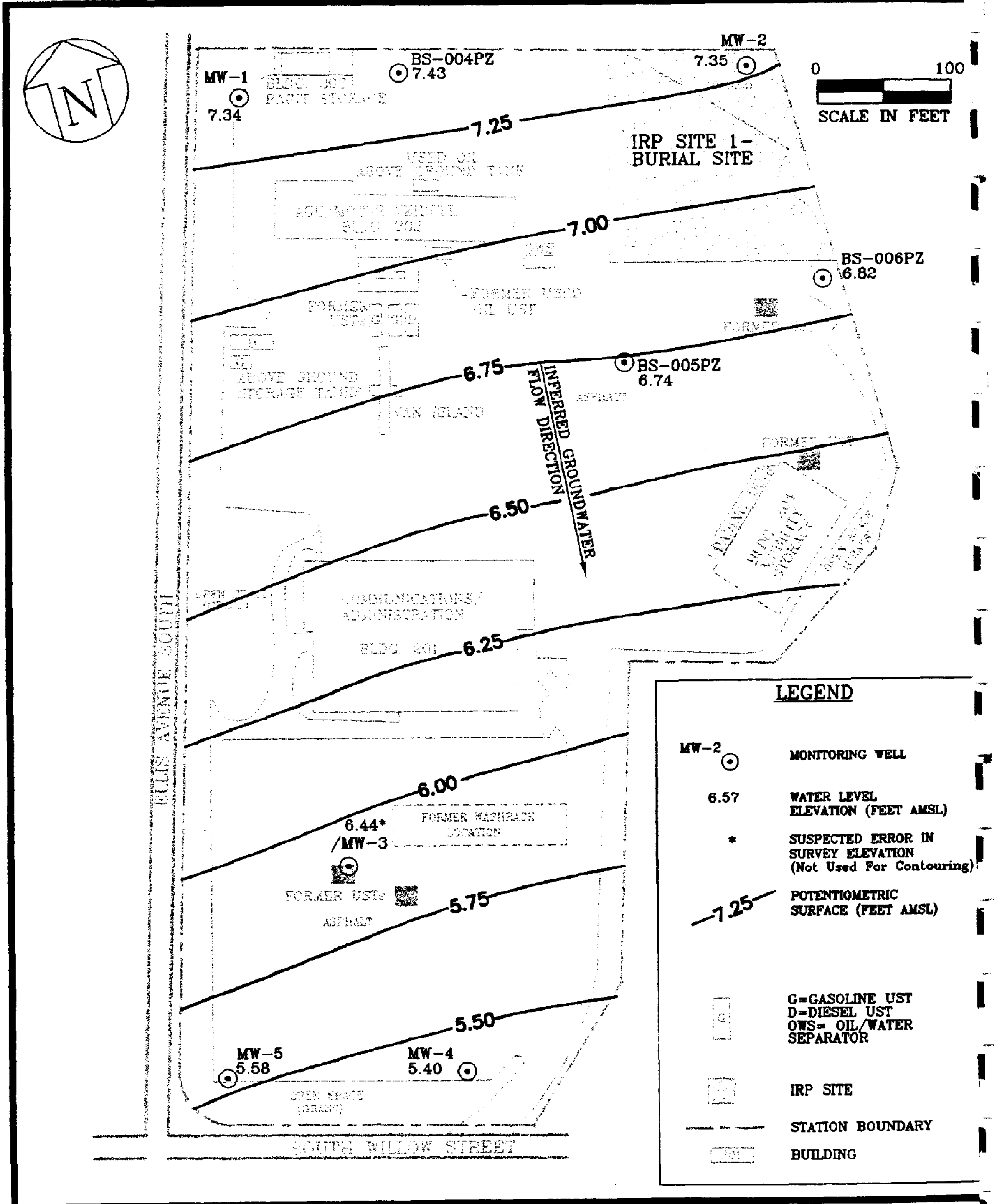

FIGURE 5-8

POTENTIOMETRIC SURFACE
APRIL 10-11, 1997
143rd CCSQ, Seattle ANGS
Seattle, Washington

ERM

60325-08.DWG

FINAL

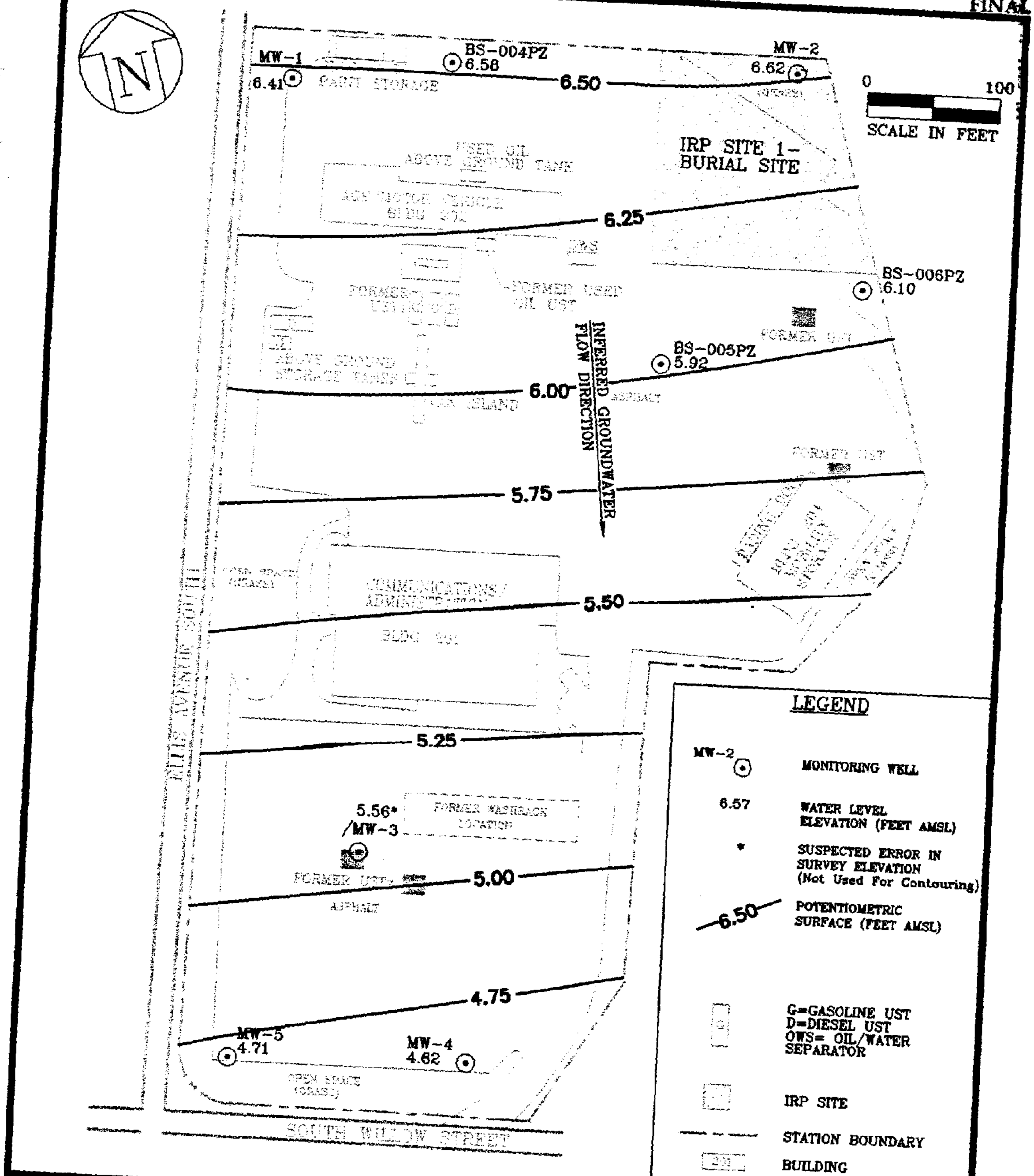

FIGURE 5-9

60325-09.DWG

POTENTIOMETRIC SURFACE
JULY 10-11, 1997

143rd CCSQ, Seattle ANGS
Seattle, Washington

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analysis, ranged from 1.25×10^{-4} to 6.09×10^{-4} feet per second (3.29 to 16.04 meters per day) using the personal-computer-based program AquiferTest. These relatively high values for hydraulic conductivity are consistent with the predominant sand lithology observed in the shallow unconfined aquifer. The relatively high hydraulic conductivity also provides an explanation for the observed rapid response of groundwater elevations to seasonal fluctuations in precipitation. Table 5-2 summarizes the results of the slug tests. The slug test data are included in Appendix E.

5.2 Project Screening Goals

Numeric project screening goals (PSGs) were developed for constituents that were detected in background and site-characterization soil and groundwater samples during the RI. The PSGs were derived from chemical-specific ARARs, and were used to: (a) evaluate detected constituent concentrations for compliance with applicable regulatory criteria; and (b) screen detected constituents for inclusion in the baseline risk assessment. ARARs are discussed further in Section 6.0. The constituent screening for the baseline risk assessment and the methods and results of the risk assessment are presented in Sections 7.0 and 8.0, respectively.

The PSGs were derived according to the following criteria:

Soil PSGs

1. The MTCA Method A Table Value (residential soil cleanup level; Washington Administrative Code [WAC] 173-340-740[2]) was used as the initial PSG.

2. If there was no MTCA Method A Table Value available, the MTCA Method B Formula Value (WAC 173-340-740[3]; WDOE, 1994b) was used as the initial PSG (cancer or non-cancer value, whichever was more stringent).

3. The regional natural background concentration was used if there was no MTCA Method A or Method B value available, or if the MTCA Method A (or Method B) value was less than the natural background concentration.

TABLE 5-2

Results for Slug Tests Conducted at Monitoring Well MW-3
143rd CCSQ, Seattle ANGS, Seattle, Washington

Test Number	Date	Type	Method of Analysis	Hydraulic Conductivity (ft/s)	Hydraulic Conductivity (m/day)
1	5/2/97	Falling Head	Bouwer & Rice	1.41E-04	3.71
2	5/2/97	Rising Head	Bouwer & Rice	3.10E-04	8.16
3	5/2/97	Falling Head	Bouwer & Rice	1.25E-04	3.29
4	5/2/97	Rising Head	Bouwer & Rice	2.22E-04	5.85
5	5/2/97	Falling Head	Bouwer & Rice	1.31E-04	3.45
6	5/2/97	Rising Head	Bouwer & Rice	6.09E-04	16.04

ft/s = Feet per second
m/day = Meters per day

4. If there was no MTCA Method A, MTCA Method B, or natural background concentration value available, the site-specific background concentration (95 percent UCL mean concentration; Table 5-3) was used.

Groundwater PSGs

1. The MTCA Method A Table Value (groundwater cleanup level; WAC 173-340-720[2]) or the Federal Safe Drinking Water Act Primary MCL or Secondary Maximum Contaminant Level (SMCL; 40 Code of Federal Regulations 141.11-16, 141.60-63, and 143.3) was used, whichever was more stringent.

2. If there was no MTCA Method A Table Value or MCL/SMCL available, the MTCA Method B Formula Value (WAC 173-340-720[3]; WDOE, 1994b) was used (cancer or non-cancer value, whichever was more stringent).

3. If there was no MTCA Method A, MCL/SMCL, or MTCA Method B value available, the site-specific background concentration (95 percent UCL mean concentration; Table 5-4) was used (data on regional natural background concentrations were not available for the constituents detected).

The PSGs used for this project and the numeric ARARs from which they were derived are summarized on Tables 5-3 and 5-4.

5.3 Background Sampling Results

The RI included the collection of site-specific background soil and groundwater samples. This section summarizes the results of the RI background sampling. The repositories of full laboratory analytical data packages are listed in Appendix F. Copies of the laboratory analytical data sheets for the background samples are included in Appendix I.

5.3.1 Background Soil Investigation Results

Three background soil borings (SB-1 through SB-3) were drilled and sampled during the RI, in areas of the Station with no known or suspected contamination. Subsurface soil samples were collected from these borings

TABLE 5-3

Numeric ARARs and Project Screening Goals for Constituents Detected in Soil
143rd CCSQ, Seattle ANGS, Seattle, Washington

Analyte	MTCA Method A Table Value (Residential Soil)	MTCA Method A Table Value (Industrial Soil)	MTCA Method B Cancer Formula Value	MTCA Method B Non-Cancer Formula Value	Regional Natural Background Concentration	Site-Specific Background Concentration*	Project Screening Goal
Organic Compounds: (mg/kg)							
Bis(2-ethylhexyl)phthalate	--	--	71.4	1,600	--	ND	71.4
TPH-Gasoline	100	100	--	--	--	ND	100
TPH-Diesel	200	200	--	--	--	ND	200
TPH-Heavy oil	200	200	--	--	--	ND	200
Trichloroethene	0.5	0.5	90.9	--	--	ND	0.5
Radionuclides: (pCi/g)							
Gross Alpha	--	--	--	--	--	9.96	9.96
Gross Beta	--	--	--	--	--	16.1	16.1
Radium-226	--	--	--	--	--	0.77	0.77
Radium-228	--	--	--	--	--	0.93	0.93
Metals: (mg/kg)							
Arsenic	20	200	1.43	60	7.3	5.59	20
Cadmium	2	10	0.164	80	0.77	ND	2
Chromium	100	500	--	--	48.15	14.2	100
Copper	--	--	--	2,960	36.36	15.8	2,960
Lead	250	1,000	--	--	16.83	18.2	250
Nickel	--	--	--	1,600	38.19	10.5	1,600
Selenium	--	--	--	400	--	1.66	400
Zinc	--	--	--	24,000	85.06	30.1	24,000

mg/kg = milligrams per kilogram
pCi/g = picoCuries per gram
MTCA = Model Toxics Control Act
-- = Standard not established/value not available
* Site-specific background concentration corresponds to the 95% upper confidence limit (UCL) mean concentration in RI background samples.
ND = Compound not detected in RI background samples.
Sources:
MTCA Method A Table Values: WAC 173-340-740 (Table 2) and WAC 173-340-745 (Table 3), MTCA Method A Cleanup Levels for Soil
MTCA Method B Formula Values: MTCA Cleanup Levels and Risk Calculations (CLARC II) Update, 1995
Regional Natural Background Concentrations: Natural Background Soil Metals Concentrations in Washington State, October 1994 (Washington State Department of Ecology Publication 94-115), Table 17, Puget Sound 90th percentile values.

TABLE 5-4

Numeric ARARs and Project Screening Goals for Constituents Detected in Groundwater
143rd CCSQ, Seattle ANGS, Seattle, Washington

Analyte	MTCA Method A Table Value	Federal Primary MCL	Federal Secondary MCL	MTCA Method B Cancer Formula Value	MTCA Method B Non-Cancer Formula Value	Site-Specific Background Concentration*	Project Screening Goal
Organic Compounds: (µg/l)							
Acetone	--	--	--	--	800	ND	800
Benzene	5	5	--	1.51	--	ND	5
1,1-Dichloroethane	--	--	--	--	800	0.513	800
1,2-Dichloroethane	5	5	--	0.481	--	ND	5
cis-1, 2-Dichloroethene	--	70	--	--	80	ND	70
Ethylbenzene	30	700	--	--	800	ND	30
Tetrachloroethene	5	5	--	0.858	80	7.33	5
Toluene	40	1,000	--	--	1,600	1.04	40
1,1,1-Trichloroethane	200	200	--	--	7,200	2.63	200
Trichloroethene	5	5	--	3.98	--	ND	5
1,3,5-Trimethylbenzene	--	--	--	--	--	0.507	0.507
Xylenes	20	10,000	--	--	16,000	ND	20
Radionuclides:							
Gross Alpha	15 pCi/l	15 pCi/l	--	--	--	1.89 pCi/l	15 pCi/l
Gross Beta	4 mrem/yr	4 mrem/yr	--	--	--	11.3 pCi/l	11.3 pCi/l (1)
Radium-226	3 pCi/l	--	--	--	--	0.236 pCi/l	3pCi/l
Radium-226 and 228	5 pCi/l	5 pCi/l	--	--	--	0.494 pCi/l	5 pCi/l
Radium-228	2 pCi/l (2)	--	--	--	--	0.258 pCi/l	2 pCi/l
Metals: (µg/l)							
Arsenic	5	50	--	0.05	4.8	ND	5
Copper	--	--	1,000	--	592	8.06	1,000
Nickel	--	100	--	--	320	9.66	100
Zinc	--	--	5,000	--	4,800	51	5,000

µg/l = micrograms per liter
pCi/l = picoCuries per liter
mrem/yr = millirem per year
-- = Standard not established
MTCA = Model Toxics Control Act
MCL = Maximum Contaminant Level (Enforceable Level) for drinking water
ND = Compound not detected in RI background samples.
(1) = The site-specific background concentration for gross beta radiation was chosen as the Project Screening Goal rather than the MTCA Method A Table Value because laboratory results were reported as concentrations, not dosages. The MTCA Method A Table Value is given as a dosage, and is thus not as easily compared with sample results.
(2) = MTCA Method A Tables for groundwater report a combined Radium-226 and Radium-228 cleanup level of 5 piC/l. The cleanup level for Radium-226 alone is 3 piC/l. Therefore, the cleanup level for Radium-228 alone is approximated at 2 piC/l.
*Site-specific background concentration corresponds to the 95% upper confidence limit (UCL) mean concentration in RI background samples.
Sources: MTCA Method A Table Values: WAC 173-340-720, MTCA Method A Cleanup Levels for Groundwater
MTCA Method B Formula Values: MTCA Cleanup Levels and Risk Calculations (CLARC II) Update, 1995
Primary and Secondary MCLs: 40 Code of Federal Regulations 141.11-16, 141.60-63, and 143.3

summarized on Table 5-5. Maximum concentrations of constituents detected in subsurface soil samples are displayed on Figures 5-12 and 5-13.

No SVOCs or TPH were detected in the background soil samples. Radionuclides were detected in all of the background soil samples. Two detections of gross alpha, and one detection each of gross beta, radium-226, and radium-228, exceed the 95 percent UCL mean background concentrations of these constituents. Trace metals detected in the background soil samples include arsenic, chromium, copper, lead, nickel, selenium, and zinc. None of these metals were detected at concentrations above PSGs.

5.3.2 Background Groundwater Investigation Results

Nine groundwater samples were collected from background monitoring wells BS-004PZ and MW-1 during the RI. These samples were analyzed for VOCs, SVOCs, TPH, radionuclides, and priority pollutant trace metals. Constituents detected in the background groundwater samples are summarized on Table 5-6. Maximum concentrations of constituents detected in groundwater samples are displayed on Figures 5-15 and 5-16. Note that negative concentration values reported for some radionuclides on Table 5-6 are a numerical artifact of the laboratory data reduction methodology for radionuclides.

No SVOCs or TPH were detected in the background groundwater samples. VOCs detected in the background groundwater samples include 1,1-dichloroethane, tetrachloroethene (PCE), 1,1,1-trichloroethane, and toluene. The concentrations of PCE reported in two samples from monitoring well BS-004PZ exceed the MTCA Method A Cleanup Level. None of the other VOCs were detected at concentrations exceeding PSGs. Radionuclides were detected in the majority of the background groundwater samples. Two detections of gross beta exceed the 95 percent UCL mean background concentration of this constituent. Trace metals detected in the background groundwater samples include copper, nickel, and zinc. None of these metals were detected at concentrations above PSGs.

TABLE 5-5

Constituents Detected in Background Soil Samples
143rd CCSQ, Seattle ANGS, Seattle, Washington

Location	Date	Sample Depth (ft-bgs)	Radionuclides (pCi/g)								Trace Metals (mg/kg)						
			Gross Alpha	(+/-)	Gross Beta	(+/-)	Radium-226	(+/-)	Radium-228	(+/-)	Arsenic	Chromium	Copper	Lead	Nickel	Selenium	Zinc
SB-1	10/15/96	3.0	11	5.5	16	4.3	0.29	0.17	0.46	0.68	6.7	14	19	15	10	ND	27
		7.0	8	5.0	15.1	4.1	0.69	0.21	1.34	0.68	2.2	8	6	ND	7	0.6	15
		9.0	7.6	5.3	16.6	4.2	0.74	0.22	0.69	0.43	1.8	10	7	ND	6	ND	16
SB-2	10/15/96	5.0	6.3	4.9	12.7	4.0	0.71	0.22	0.70	0.38	7	14	20	33	12	2.2	45
		7.0	7.5	4.9	14.5	4.2	0.88	0.24	0.77	0.43	2.6	13	17	14	9	1.5	26
		9.0	9.2	5.1	16.1	4.5	0.31	0.16	0.82	0.18	2.5	15	10	11	7	1.4	21
SB-3	10/15/96	3.0	12.8	5.9	15.7	4.2	0.76	0.24	0.87	0.42	8.7	17	15	20	14	2.8	30
		7.0	8.1	5.3	16.0	4.1	0.66	0.23	0.38	0.40	0.8	10	8	6	6	ND	14
		9.0	6.8	5.0	15.3	4.1	0.71	0.23	0.76	0.48	2.7	8	7	ND	7	ND	19
95% UCL Mean Concentration			9.96		16.1		0.77		0.93		5.59	14.2	15.8	18.2	10.5	1.66	30.1
Project Screening Goal			9.96		16.1		0.77		0.93		20	100	2,960	250	1,600	400	24,000

RI = Remedial Investigation
µg/kg = Micrograms per kilogram
mg/kg = Milligrams per kilogram
pCi/g = picoCuries per gram
ND = Not detected above laboratory method reporting limit
ft-bgs = Feet below ground surface
+/- = Margin of error (pCi/g)
NA = Not analyzed
UCL = Upper confidence limit
Note:
The 95% UCL mean concentration calculation included all RI background samples. For samples that were "ND" for a given constituent, a value equal to one-half of the associated method reporting limit was used in the 95% UCL mean concentration calculation (per WAC 173-340-708).
Shaded cells indicate a detection above the associated Project Screening Goal or ARAR.

TABLE 5-6

Constituents Detected in Background Groundwater Samples
143rd CCSQ, Seattle ANGS, Seattle, Washington

Location	Date	Volatile Organic Compounds (µg/l)				Radionuclides (pCi/l)								Trace Metals (µg/l)		
		1,1-DCA	PCE	1,1,1-TCA	Toluene	Gross Alpha	(+/-)	Gross Beta	(+/-)	Radium-226	(+/-)	Radium-228	(+/-)	Copper	Nickel	Zinc
BS-004PZ	9/17/96	0.3	3.8	3.7	(ND)	2.2	1.7	13.2	2.1	0.2	0.18	-0.08	0.51	ND	ND	ND
	9/17/96 (dup)	0.3	3.8	3.8	(ND)	0.2	1.1	11.7	2	0.19	0.15	-0.6	0.45	ND	ND	ND
	1/14/97	ND	5.1	2.4	ND	2.1	1.5	9.9	1.8	0.02	0.12	0.25	0.4	ND	ND	61
	4/11/97	ND	17	3.3	ND	1.3	1.3	6.8	1.7	0.04	0.12	0.29	0.38	5	ND	(ND)
	7/10/97	ND	(ND)	1.8	ND	0.9	1.2	8.6	1.8	0.05	0.13	0.22	0.41	6	ND	(ND)
MW-1	10/18/96	ND	ND	ND	ND	0.5	1	8.1	1.8	0.27	0.18	0.08	0.44	ND	ND	ND
	12/17/96	ND	ND	ND	ND	3.9	1.9	12.7	2.1	0.18	0.18	0.2	0.37	ND	8	(ND)
	1/14/97	ND	ND	ND	1.1	-0.09	0.84	10.4	1.9	0.35	0.24	0.31	0.44	ND	8	61
	4/11/97	ND	ND	ND	ND	0	1.1	10.3	1.9	0.22	0.15	0.02	0.37	ND	13	(ND)
	7/11/97	ND	ND	ND	ND	-0.3	1	9	1.8	0.19	0.16	0.2	0.6	19	7	(ND)
95% UCL Mean Concentration		0.513	7.33	2.63	1.04	1.89		11.3		0.236		0.258		8.06	9.66	51
Project Screening Goal		800	5	200	40	15		11.3		3		2		1,000	100	5,000

RI = Remedial Investigation
ND = Not detected above laboratory method reporting limit
(ND) = A positive detection was reported by the laboratory for this constituent in the sample indicated. The sample result was qualified as not detected based on a detection of the constituent in an associated quality control blank (United States Environmental Protection Agency Contract Laboratory Program "10x" and "5x" rules).
pCi/l = picoCuries per liter
µg/l = micrograms per liter
mg/l = milligrams per liter
+/- = Margin of error (pCi/l)
dup = Duplicate sample
UCL = Upper confidence limit

Constituent Abbreviations
1,1-DCA = 1,1-Dichloroethane
PCE = Tetrachloroethene
1,1,1-TCA = 1,1,1-Trichloroethane

Note:
The 95% UCL mean concentration calculation included all RI background samples. For samples that were "ND" for a given constituent, a value equal to one-half of the associated method reporting limit was used in the calculation (per WAC 173-340-708).
Shaded cells indicate a detection above the associated Project Screening Goal or ARAR.

5.4 IRP Site 1 - Burial Site and Sitewide Investigation

This section presents the field-screening and analytical testing results for the site-characterization and QA/QC samples collected at the IRP site and throughout the Seattle ANGS during the RI. The repositories of full laboratory analytical data packages are listed in Appendix F. Copies of the laboratory analytical data summary sheets for the site-characterization and QA/QC samples are included in Appendix I.

5.4.1 Geoprobe/HydroPunch Results

A Geoprobe/HydroPunch investigation was conducted prior to the installation of soil borings and monitoring wells to provide chemical data for groundwater downgradient of the IRP site and to provide sitewide groundwater quality data. Groundwater samples were analyzed in a mobile field laboratory for VOCs and TPH. Results of the Geoprobe/HydroPunch investigation were evaluated to select final locations for soil borings and groundwater monitoring wells.

Constituents detected in groundwater samples collected during the Geoprobe/HydroPunch investigation are summarized on Table 5-7 and displayed on Figure 5-10. A summary of the Geoprobe/HydroPunch groundwater analytical results is provided below.

5.4.1.1 Volatile Organic Compounds

VOCs detected in the Geoprobe/HydroPunch groundwater samples include benzene, toluene, ethylbenzene, xylenes, cis-1,2-dichloroethene, 1,2-dichloroethane, 1,1,1-trichloroethane, and trichloroethene (TCE). The concentrations of benzene (7.6 micrograms per liter [μg/l]) and TCE (17 μg/l) detected at locations GP-3 and GP-4, respectively, exceed the MTCA Method A Cleanup Levels for these constituents.

5.4.1.2 Total Petroleum Hydrocarbons

No TPH was detected in the Geoprobe/HydroPunch groundwater samples.

TABLE 5-7

Constituents Detected in Site-Characterization Groundwater Samples Collected from Geoprobe/HydroPunch Locations
143rd CCSQ, Seattle ANGS, Seattle, Washington

Location	Date	Benzene	Toluene	Ethylbenzene	Total Xylenes	Cis-1,2-Dichloroethene	1,2-Dichloroethane	1,1,1-Trichloroethane	Trichloroethene
GP-2	10/8/96	ND	ND	ND	ND	2	ND	ND	3.7
GP-3	10/8/96	7.6	ND	ND	ND	ND	2.4	ND	ND
GP-4	10/8/96	ND	ND	ND	ND	2	ND	ND	17
GP-5	10/8/96	2.7	1.6	9.9	ND	3.9	ND	ND	4.1
GP-15	10/9/96	ND	ND	ND	ND	5	ND	ND	ND
GP-22	10/9/96	ND	ND	ND	7	ND	ND	2	ND
Project Screening Goal		5	40	30	20	70	5	200	5

All concentrations in micrograms per liter (μg/l).
ND = Not detected above laboratory method reporting limit
Shaded cells indicate a detection above the associated Project Screening Goal
Note: Only the results for samples with target analyte detections are shown; samples that were "ND" for all target analytes are not shown.

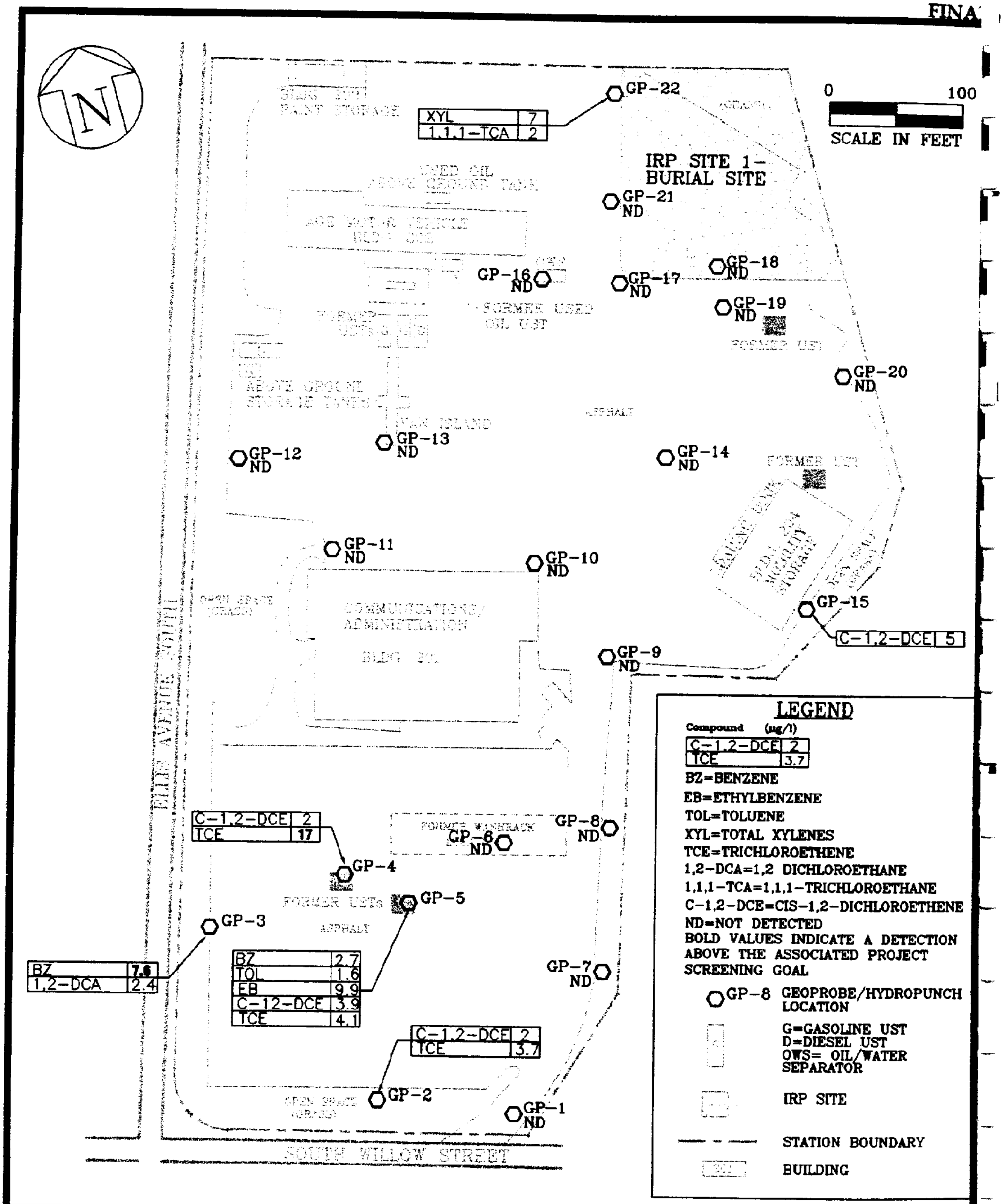

FIGURE 5-10

CONSTITUENTS
DETECTED IN GEOPROBE/HYDROPUNCH
GROUNDWATER SAMPLES
143rd CCSQ, Seattle ANGS
Seattle, Washington

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5.4.2 Field-Screening Results

Field-screening for organic vapors was conducted on soil samples collected during the RI using a PID. The results of organic vapor screening conducted on surface soil samples are documented in the RI field notes. The results of organic vapor screening conducted on subsurface soil samples are documented on the borehole logs contained in Appendix B. The organic vapor concentrations measured for surface and subsurface soil samples did not exceed ambient background levels at the Seattle ANGS.

Field-screening of soil samples for TPH was also conducted, using a field immunoassay test kit. The results of the TPH field-screening are documented on the test kit data sheets included in Appendix G and on soil boring and monitoring well logs in Appendix B. The TPH field-screening results did not correlate well with the laboratory TPH results for soil samples. TPH was detected by the laboratory in five surface soil samples at concentrations ranging from 23 mg/kg to 110 mg/kg. Field-screening did not detect any TPH in these samples above the method detection limit of 15 mg/kg.

5.4.3 Surface Soil Investigation Results

A hand-drive sampler was used to collect surface soil samples from locations SS-1 through SS-10. Surface soil samples were analyzed for TPH and radionuclides. As outlined in the RI/FS Work Plan, samples to be analyzed for VOCs and SVOCs were selected based on field-screening results (i.e., organic vapor and TPH screening). Organic vapors were not detected in any surface soil samples, and field-screening detected TPH in only two of the ten samples. Consequently, surface soil samples were not analyzed for VOCs or SVOCs. Constituents detected in the site-characterization surface soil samples are summarized on Table 5-8 and displayed on Figure 5-11.

5.4.3.1 Total Petroleum Hydrocarbons

TPH was detected in five site-characterization surface soil samples. None of the detected concentrations exceed PSGs.

TABLE 5-8

Constituents Detected in Site-Characterization Surface Soil Samples
143rd CCSQ, Seattle ANGS, Seattle, Washington

Location	Date	Depth (ft-bgs)	Total Petroleum Hydrocarbons (mg/kg)			Radionuclides (pCi/g)							
			Gasoline	Diesel	Heavy Oil	Gross Alpha	(+/-)	Gross Beta	(+/-)	Radium-226	(+/-)	Radium-228	(+/-)
SS-01	10/17/96	0.5	ND	ND	ND	7.4	4.8	16.6	4.3	0.48	0.20	0.82	0.48
SS-02	10/17/96	0.5	ND	ND	ND	6.1	4.6	13.2	4.0	0.57	0.23	0.57	0.42
SS-03	10/17/96	0.5	23	63	ND	10.5	5.3	14.7	4.2	0.44	0.20	0.23	0.39
SS-04	10/17/96	0.5	ND	ND	ND	10.3	5.5	13	4.1	0.54	0.19	0.59	0.41
SS-05	10/17/96	0.5	ND	ND	ND	7.3	5.0	14.6	4.2	0.53	0.22	0.64	0.41
SS-06	10/17/96	0.5	ND	ND	ND	4	4.2	9	3.9	0.23	0.17	0.48	0.48
SS-06 (dup)	10/17/96	0.5	ND	ND	ND	3.4	4.2	8.5	3.8	0.29	0.17	0.7	0.43
SS-07	10/17/96	0.5	ND	70	ND	3	4.7	13.1	4.1	0.44	0.20	0.54	0.44
SS-08	10/17/96	0.5	ND	ND	102	7.5	4.9	8.9	3.7	0.39	0.19	0.83	0.45
SS-09	10/17/96	0.5	ND	66	110	11.9	5.9	12.9	3.9	0.65	0.17	0.71	0.78
SS-10	10/17/96	0.5	35	ND	ND	6.5	4.6	14.3	4.0	0.65	0.23	0.42	0.57
Project Screening Goal			100	200	200	9.96		16.1		0.77		0.93	

ft-bgs = Feet below ground surface
dup = Duplicate sample
mg/kg = Milligrams per kilogram
pCi/g = picoCuries per gram
+/- = Margin of error (pCi/g)
ND = Not detected above laboratory method reporting limit
Shaded cells indicate a detection above the associated Project Screening Goal

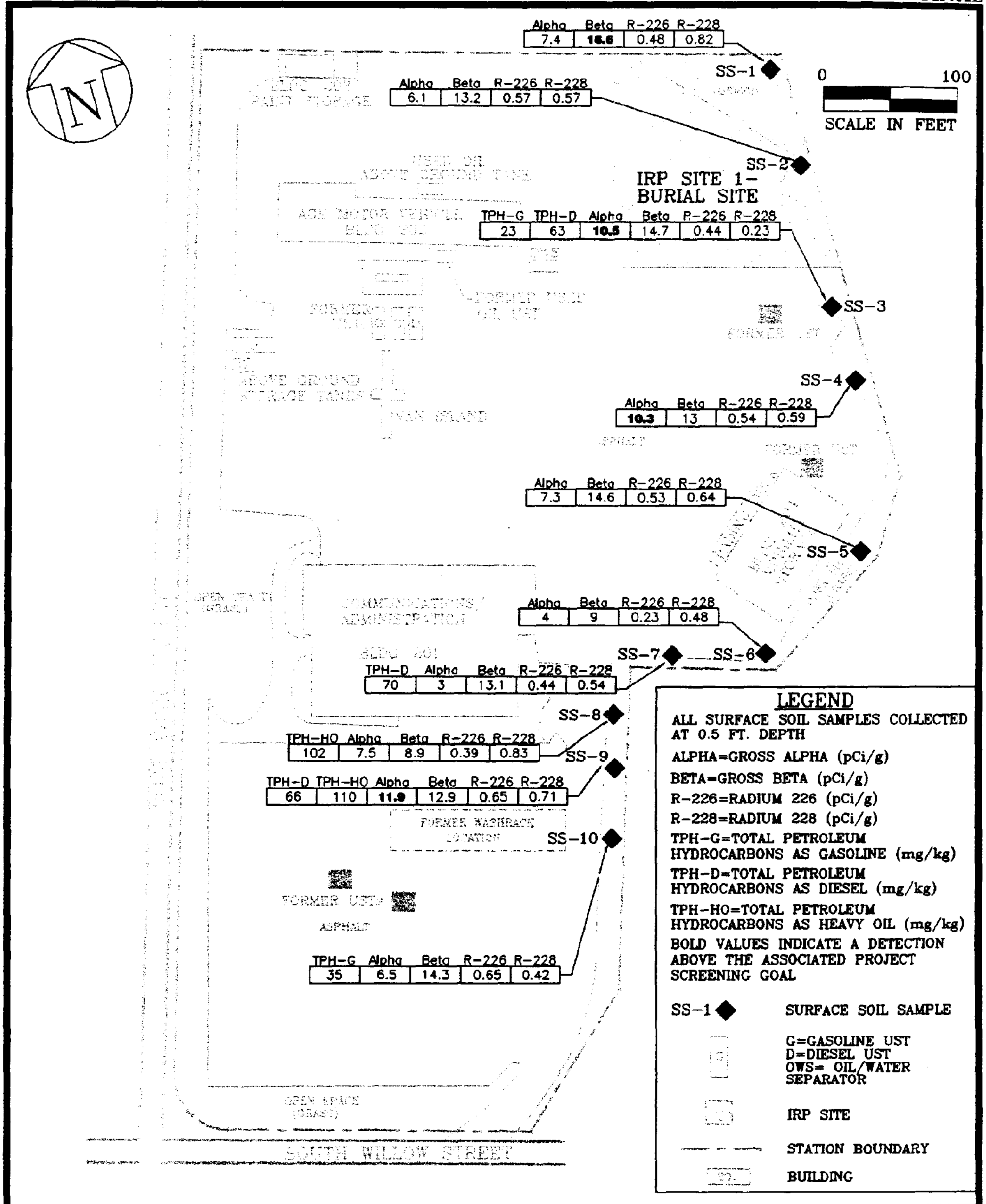

FIGURE 5-11

CONSTITUENTS DETECTED IN SURFACE SOIL SAMPLES
143rd CCSQ, Seattle ANGS
Seattle, Washington

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60325-11.DWG

5.4.3.2 Radionuclides

Radionuclides were detected in all of the site-characterization surface soil samples. Three detections of gross alpha and one detection of gross beta exceed the 95 percent UCL mean background concentrations of these constituents.

5.4.4 Subsurface Soil Investigation Results

A split-spoon drive sampler was used to collect subsurface soil samples from soil borings SB-4 through SB-11 within the IRP site boundary. In addition, subsurface soil samples were collected from the soil boring for monitoring well MW-3 in the southern portion of the Station. Constituents detected in the site-characterization subsurface soil samples are summarized on Table 5-9. Maximum concentrations of constituents detected in subsurface soil samples are displayed on Figures 5-12 and 5-13.

5.4.4.1 Volatile Organic Compounds

As outlined in the RI/FS Work Plan, VOC analyses were not conducted on subsurface soil samples unless field-screening with a PID indicated the presence of VOCs. The PID did not detect organic vapors above ambient background concentrations in any of the subsurface soil samples. Consequently, subsurface soil samples collected from the RI soil borings were not analyzed for VOCs. However, two soil samples collected from the borehole for monitoring well MW-3 were analyzed for VOCs based on a detection of TCE in the Geoprobe/HydroPunch groundwater sample collected at this location.

TCE was the only constituent detected in the two subsurface soil samples analyzed for VOCs. TCE was detected at a concentration below the associated PSG in the soil sample collected from 9 feet bgs at monitoring well MW-3. Based on water level data for monitoring well MW-3 (Table 5-1), this soil sample was most likely collected at or below the water table, and the TCE detected in the sample is most likely the result of groundwater impacted by VOCs in this area.

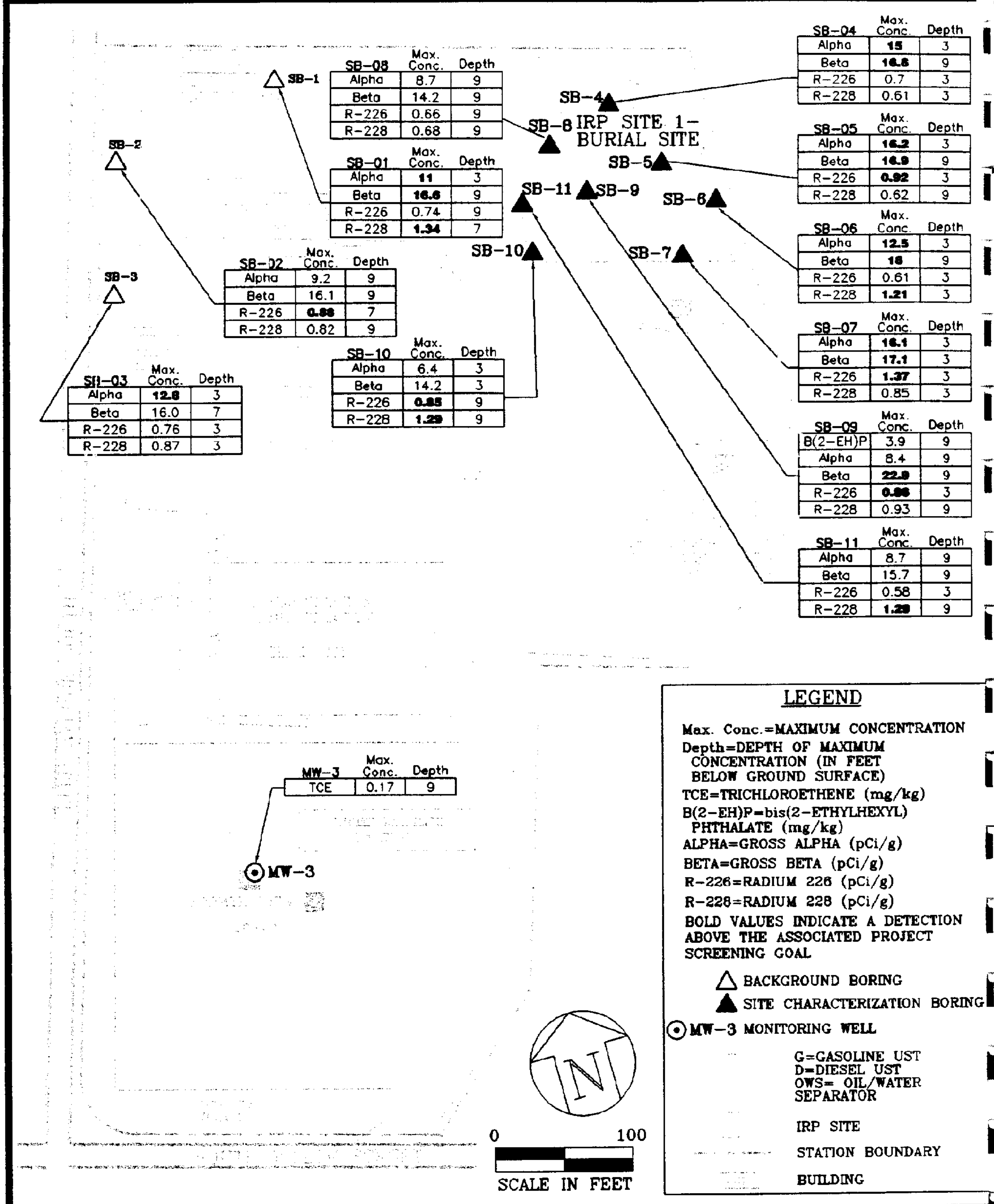
TABLE 5-9

Constituents Detected in Site-Characterization Subsurface Soil Samples
143rd CCSQ, Seattle ANGS, Seattle, Washington

			VOCs (mg/kg)	SVOCs (mg/kg)	Radionuclides (pCi/g)								Trace Metals (mg/kg)							
Location	Date	Depth (ft-bgs)	TCE	B(2-EH)P	Gross Alpha	(+/-)	Gross Beta	(+/-)	Radium-226	(+/-)	Radium-228	(+/-)	Arsenic	Cadmium	Chromium	Copper	Lead	Nickel	Selenium	Zinc
SB-04	10/15/96	3	NA	ND	15	6.1	14.7	4.0	0.7	0.24	0.61	0.39	11	0.8	16	35	110	16	1.5	100
SB-04	10/15/96	9	NA	ND	6.7	4.7	16.6	4.2	0.62	0.22	0.13	0.58	4.8	ND	17	23	19	10	1.4	39
SB-05	10/15/96	3	NA	ND	16.2	6.4	15.6	4.2	0.92	0.25	0.35	0.57	8.2	ND	14	26	45	12	1.4	47
SB-05	10/15/96	9	NA	ND	12.4	6.0	16.9	4.2	0.33	0.17	0.62	0.52	5.4	ND	19	25	18	24	1.5	40
SB-06	10/15/96	3	NA	ND	12.5	5.8	13.4	4.1	0.61	0.22	1.21	0.73	3.1	ND	16	16	10	4	0.8	10
SB-06 (dup)	10/15/96	3	NA	ND	13.1	6.0	15.5	4.2	0.48	0.20	0.76	0.57	NA	NA	NA	NA	NA	NA	NA	NA
SB-06	10/15/96	9	NA	ND	6.7	5.4	18	4.4	0.45	0.19	0.44	0.62	ND	ND	9	5	8	4	ND	14
SB-06 (dup)	10/15/96	9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2.7	ND	15	9	11	7	ND	19
SB-07	10/15/96	3	NA	ND	16.1	6.4	17.1	4.3	1.37	0.32	0.85	0.64	13	ND	12	10	19	7	ND	16
SB-07	10/15/96	9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND	ND	13	6	8	4	ND	15
SB-08	10/16/96	3	NA	ND	5	4.4	11.7	3.9	0.55	0.20	0.57	0.47	11	ND	14	31	64	13	ND	89
SB-08	10/16/96	9	NA	ND	8.7	5.9	14.2	4.2	0.66	0.21	0.68	0.44	4.5	ND	16	26	17	12	ND	38
SB-09	10/16/96	3	NA	ND	8.2	5.2	14	4.2	0.86	0.24	0.53	0.42	12	ND	13	21	76	10	ND	42
SB-09 (dup)	10/16/96	3	NA	ND	10.5	5.5	15.7	4.2	0.63	0.23	0.56	0.47	20	ND	16	28	250	14	ND	210
SB-09	10/16/96	9	NA	3.9	8.4	5.1	22.9	4.7	0.64	0.21	0.93	0.47	5.3	ND	16	18	13	16	ND	49
SB-10	10/16/96	3	NA	ND	6.4	4.9	14.2	4.1	0.76	0.26	1.01	0.45	4.3	ND	10	11	11	7	ND	19
SB-10	10/16/96	9	NA	ND	5.8	4.5	13.4	3.9	0.85	0.26	1.29	0.52	4.6	ND	11	15	18	7	ND	22
SB-11	10/16/96	3	NA	ND	4.9	4.5	14.7	4.1	0.58	0.21	0.54	0.48	4	ND	11	18	15	7	ND	28
SB-11	10/16/96	9	NA	ND	8.7	5.8	15.7	4.3	0.47	0.21	1.29	0.51	6.9	ND	18	22	20	20	ND	43
MW-3	10/17/96	5	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MW-3	10/17/96	9	0.17	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Project Screening Goal			0.5	71.4	9.96		16.1		0.77		0.93		20	2	100	2,960	250	1,600	400	24,000

VOCs = Volatile organic compounds
SVOCs = Semivolatile organic compounds
TCE = Trichloroethene
B(2-EH)P = Bis(2-ethylhexyl)phthalate
mg/kg = Milligrams per kilogram
pCi/g = picoCuries per gram
µg/kg = Micrograms per kilogram
Shaded cells indicate a detection above the associated Project Screening Goal

ft-bgs = Feet below ground surface
ND = Not detected above laboratory method reporting limit
NA = Not analyzed
+/- = Margin of error (pCi/g)
dup = Duplicate sample



SB-08	Max. Conc.	Depth
Alpha	8.7	9
Beta	14.2	9
R-226	0.66	9
R-228	0.68	9

SB-01	Max. Conc.	Depth
Alpha	**11**	3
Beta	**16.6**	9
R-226	0.74	9
R-228	**1.34**	7

SB-02	Max. Conc.	Depth
Alpha	9.2	9
Beta	16.1	9
R-226	**0.88**	7
R-228	0.82	9

SB-03	Max. Conc.	Depth
Alpha	**12.8**	3
Beta	16.0	7
R-226	0.76	3
R-228	0.87	3

SB-10	Max. Conc.	Depth
Alpha	6.4	3
Beta	14.2	3
R-226	**0.85**	9
R-228	**1.29**	9

SB-04	Max. Conc.	Depth
Alpha	**15**	3
Beta	**16.8**	9
R-226	0.7	3
R-228	0.61	3

SB-05	Max. Conc.	Depth
Alpha	**16.2**	3
Beta	**16.9**	9
R-226	**0.92**	3
R-228	0.62	9

SB-06	Max. Conc.	Depth
Alpha	**12.5**	3
Beta	**18**	9
R-226	0.61	3
R-228	**1.21**	3

SB-07	Max. Conc.	Depth
Alpha	**16.1**	3
Beta	**17.1**	3
R-226	**1.37**	3
R-228	0.85	3

SB-09	Max. Conc.	Depth
B(2-EH)P	3.9	9
Alpha	8.4	9
Beta	**22.9**	9
R-226	**0.86**	3
R-228	0.93	9

SB-11	Max. Conc.	Depth
Alpha	8.7	9
Beta	15.7	9
R-226	0.58	3
R-228	**1.29**	9

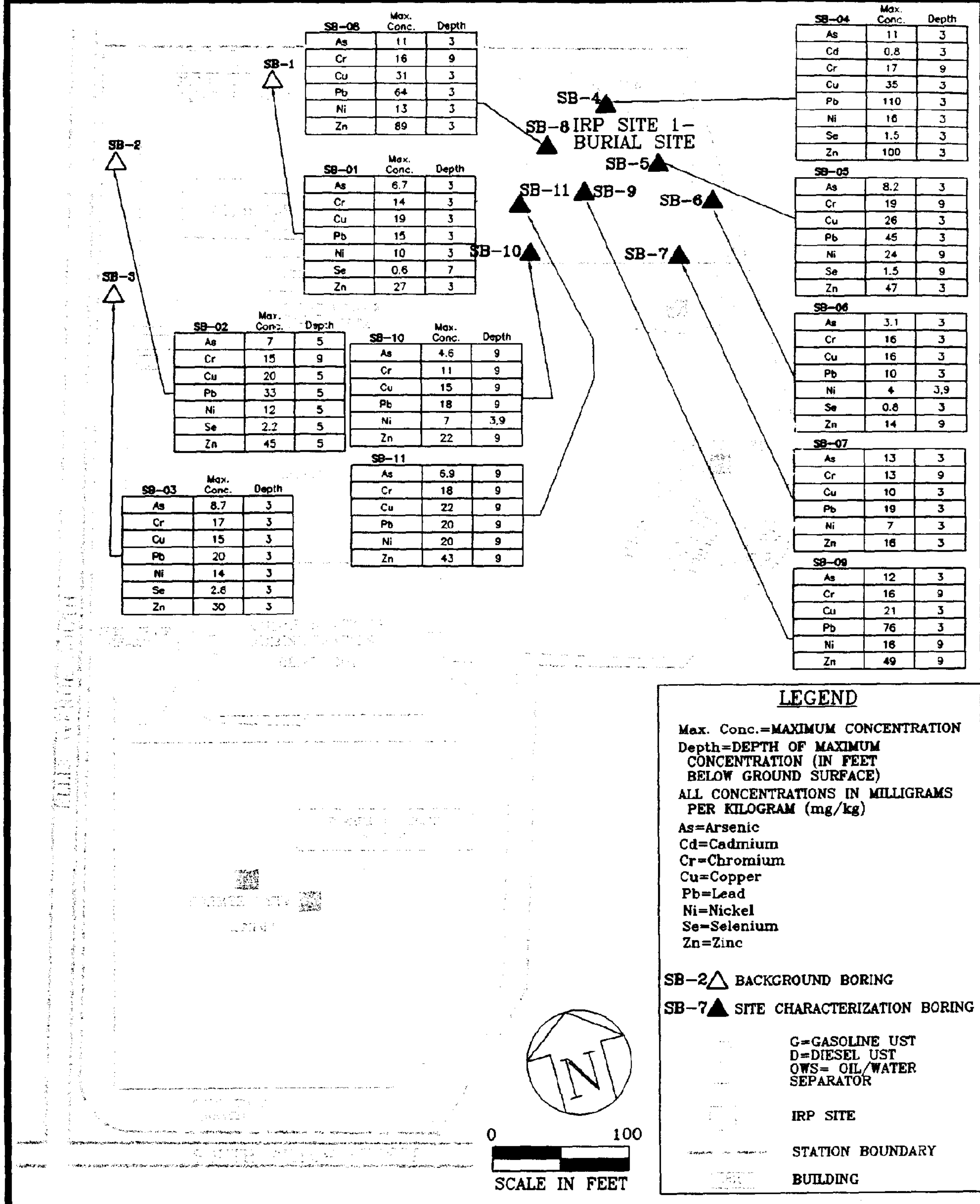
MW-3	Max. Conc.	Depth
TCE	0.17	9

FIGURE 5-12

MAXIMUM CONCENTRATIONS OF ORGANIC COMPOUNDS AND RADIONUCLIDES DETECTED IN SUBSURFACE SOIL SAMPLES
143rd CCSQ, Seattle ANGS
Seattle, Washington

ERM

60325-12.DWG



SB-08	Max. Conc.	Depth
As	11	3
Cr	16	9
Cu	31	3
Pb	64	3
Ni	13	3
Zn	89	3

SB-04	Max. Conc.	Depth
As	11	3
Cd	0.8	3
Cr	17	9
Cu	35	3
Pb	110	3
Ni	16	3
Se	1.5	3
Zn	100	3

SB-01	Max. Conc.	Depth
As	6.7	3
Cr	14	3
Cu	19	3
Pb	15	3
Ni	10	3
Se	0.6	7
Zn	27	3

SB-05	Max. Conc.	Depth
As	8.2	3
Cr	19	9
Cu	26	3
Pb	45	3
Ni	24	9
Se	1.5	9
Zn	47	3

SB-02	Max. Conc.	Depth
As	7	5
Cr	15	9
Cu	20	5
Pb	33	5
Ni	12	5
Se	2.2	5
Zn	45	5

SB-10	Max. Conc.	Depth
As	4.6	9
Cr	11	9
Cu	15	9
Pb	18	9
Ni	7	3,9
Zn	22	9

SB-06	Max. Conc.	Depth
As	3.1	3
Cr	16	3
Cu	16	3
Pb	10	3
Ni	4	3,9
Se	0.8	3
Zn	14	9

SB-11	Max. Conc.	Depth
As	6.9	9
Cr	18	9
Cu	22	9
Pb	20	9
Ni	20	9
Zn	43	9

SB-03	Max. Conc.	Depth
As	8.7	3
Cr	17	3
Cu	15	3
Pb	20	3
Ni	14	3
Se	2.8	3
Zn	30	3

SB-07	Max. Conc.	Depth
As	13	3
Cr	13	9
Cu	10	3
Pb	19	3
Ni	7	3
Zn	16	3

SB-09	Max. Conc.	Depth
As	12	3
Cr	16	9
Cu	21	3
Pb	76	3
Ni	18	9
Zn	49	9

LEGEND

Max. Conc.=MAXIMUM CONCENTRATION
Depth=DEPTH OF MAXIMUM CONCENTRATION (IN FEET BELOW GROUND SURFACE)
ALL CONCENTRATIONS IN MILLIGRAMS PER KILOGRAM (mg/kg)

As=Arsenic
Cd=Cadmium
Cr=Chromium
Cu=Copper
Pb=Lead
Ni=Nickel
Se=Selenium
Zn=Zinc

SB-2 △ BACKGROUND BORING
SB-7 ▲ SITE CHARACTERIZATION BORING
G=GASOLINE UST
D=DIESEL UST
OWS= OIL/WATER SEPARATOR
IRP SITE
STATION BOUNDARY
BUILDING

FIGURE 5-13

MAXIMUM CONCENTRATIONS OF METALS DETECTED IN SUBSURFACE SOIL SAMPLES
143rd CCSQ, Seattle ANGS
Seattle, Washington

ERM

60225-13 DWG

5.4.4.2 Semivolatile Organic Compounds

Bis(2-ethylhexyl)phthalate was the only SVOC detected in the site-characterization subsurface soil samples. Bis(2-ethylhexyl)phthalate was detected at a concentration below the associated PSG in a single soil sample collected from 9 feet bgs at soil boring SB-9.

5.4.4.3 Total Petroleum Hydrocarbons

No TPH was detected in the site-characterization subsurface soil samples.

5.4.4.4 Radionuclides

Radionuclides were detected in all of the site-characterization subsurface soil samples analyzed for these constituents. Five detections each of gross alpha and gross beta, and four detections each of radium-226 and radium-228, exceed the 95 percent UCL mean background concentrations of these constituents.

5.4.4.5 Metals

Trace metals detected in the site-characterization subsurface soil samples include arsenic, cadmium, chromium, copper, lead, nickel, selenium, and zinc. None of these metals were detected at concentrations exceeding PSGs.

5.4.5 Storm Sewer Catch Basin Investigation Results

Samples collected from two storm sewer catch basins (Figure 4-2) were analyzed for VOCs, SVOCs, TPH, trace metals, and radionuclides. The catch basin samples consisted of a mixture of sediment and water, and were analyzed as a liquid matrix due to the consistency of the samples. Constituents detected in the storm sewer catch basin samples are summarized on Table 5-10 and displayed on Figure 5-14.

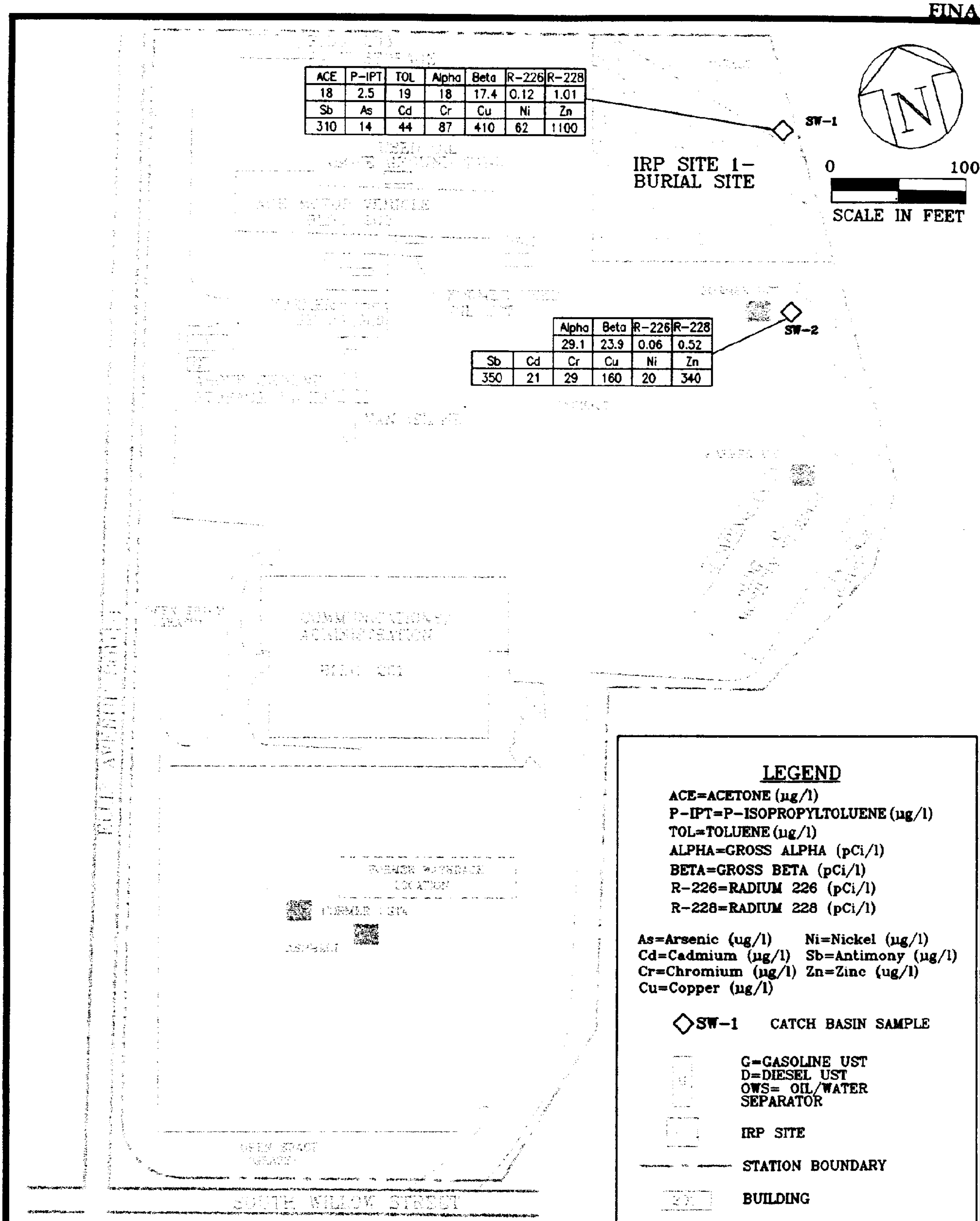
The Seattle ANGS does not have or require a stormwater permit, and there are no specific regulatory criteria governing the quality of water or sediment present in the Station's storm sewer system. Consequently, no PSGs were developed for constituents detected in the catch basin samples. However, based on the sample results summarized below and on Table 5-10, the storm sewer system does not appear to be a significant pathway for off-site migration of contaminants. Additionally, no potential sources

TABLE 5-10

Constituents Detected in Storm Sewer Catch Basin Samples
143rd CCSQ, Seattle ANGS, Seattle, Washington

Location	Date	VOCs (µg/l)			Radionuclides (pCi/l)								Trace Metals (µg/l)						
		Acetone	p-IPT	Toluene	Gross Alpha	(+/-)	Gross Beta	(+/-)	Radium-226	(+/-)	Radium-228	(+/-)	Antimony	Arsenic	Cadmium	Chromium	Copper	Nickel	Zinc
SW-1	7/11/97	18	2.5	19	18	4.6	17.4	2.9	0.12	0.16	1.01	0.48	310	14	44	87	410	62	1,100
SW-2	7/11/97	ND	ND	ND	29.1	7.6	23.9	4.6	0.06	0.14	0.52	0.60	350	ND	21	29	160	20	340

VOCs = Volatile organic compounds
p-IPT = p-isopropyltoluene
µg/l = Micrograms per liter
pCi/l = picoCuries per liter
ND = Not detected above laboratory method reporting limits
+/- = Margin of error (pCi/l)



SW-1

ACE	P-IPT	TOL	Alpha	Beta	R-226	R-228
18	2.5	19	18	17.4	0.12	1.01
Sb	As	Cd	Cr	Cu	Ni	Zn
310	14	44	87	410	62	1100

SW-2

		Alpha	Beta	R-226	R-228
		29.1	23.9	0.06	0.52
Sb	Cd	Cr	Cu	Ni	Zn
350	21	29	160	20	340

FIGURE 5-14

CONSTITUENTS DETECTED IN
STORM SEWER
CATCH BASIN SAMPLES
143rd CCSQ, Seattle ANGS
Seattle, Washington

ERM

60325-14.DWG

of the constituents detected in the catch basin samples have been identified at the Station.

5.4.5.1 Volatile Organic Compounds

The VOCs acetone, p-isopropyltoluene, and toluene were detected in catch basin sample SW-1, at concentrations ranging from 2.5 to 19 µg/l. No VOCs were detected in catch basin sample SW-2.

5.4.5.2 Semivolatile Organic Compounds

No SVOCs were detected in the storm sewer catch basin samples.

5.4.5.3 Total Petroleum Hydrocarbons

No TPH was detected in the storm sewer catch basin samples.

5.4.5.4 Radionuclides

Radionuclides were detected in the storm sewer catch basin samples at concentrations ranging from 0.06 to 29.1 picoCuries per liter (pCi/l).

5.4.5.5 Metals

Trace metals detected in the storm sewer catch basin samples include antimony, arsenic, cadmium, chromium, copper, nickel, and zinc.

5.4.6 Groundwater Investigation Results

Quarterly groundwater samples were collected at the Seattle ANGS from September 1996 though July 1997. This included a round of PA/SI monitoring-well sampling prior to commencing the RI field investigation. Monitoring wells installed during the RI were sampled immediately following well development and approximately 60 days after installation. After the initial and 60-day sampling events, the PA/SI and RI monitoring wells were sampled on a quarterly basis. Tables 5-11 through 5-13 summarize the constituents detected in site-characterization groundwater samples collected from monitoring wells. Maximum concentrations of constituents detected in monitoring-well groundwater samples are displayed on Figures 5-15 and 5-16.

TABLE 5-11

Organic Constituents Detected in Site-Characterization Groundwater Samples Collected from Monitoring Wells
143rd CCSQ, Seattle ANGS, Seattle, Washington

Location	Date	Acetone	Cis-1,2-Dichloroethene	1,3,5-Trimethylbenzene	Tetrachloroethene	Trichloroethene
BS-005PZ	9/17/96	ND	ND	0.2	ND	ND
BS-005PZ	7/11/97	ND	ND	ND	4.7	ND
BS-006PZ	9/17/96	ND	ND	0.2	ND	ND
MW-03	10/18/96	18	ND	ND	ND	ND
MW-03	10/18/96 (dup)	20	ND	ND	ND	ND
MW-04	10/18/96	11	ND	ND	ND	3.9
MW-04	12/17/96	ND	ND	ND	ND	2.7
MW-04	1/14/97	ND	ND	ND	ND	3.4
MW-04	4/11/97	ND	ND	ND	ND	3.2
MW-04	7/11/97	ND	ND	ND	ND	2.8
MW-05	10/18/96	ND	5.6	ND	ND	ND
MW-05	12/17/96	ND	4.9	ND	ND	ND
MW-05	1/14/97	ND	2.7	ND	ND	ND
MW-05	4/11/97	ND	1.4	ND	ND	ND
MW-05	4/11/97 (dup)	ND	1.6	ND	ND	ND
MW-05	7/10/97	ND	3.5	ND	(ND)	2.1
MW-05	7/10/97 (dup)	ND	2.8	ND	ND	ND
Project Screening Goal		800	70	0.507	5	5

All concentrations in micrograms per liter (μg/l)
ND = Not detected above laboratory method reporting limit.
(ND) = A positive detection was reported by the laboratory for this compound in the sample indicated. The sample result was qualified as not detected based on a detection of the compound in an associated quality control blank (United States Environmental Protection Agency Contract Laboratory Program "10x" and "5x" rules).
dup = duplicate sample
Note:
Only the results for samples with target analyte detections are shown; samples that were "ND" for all target analytes are not shown.

TABLE 5-12

Radionuclides Detected in Site-Characterization Groundwater Samples Collected from Monitoring Wells
143rd CCSQ, Seattle ANGS, Seattle, Washington

Location	Date	Gross Alpha	(+/-)	Gross Beta	(+/-)	Radium-226	(+/-)	Radium-228	(+/-)
BS-005PZ	9/17/96	0	1.7	**20**	3.0	0.07	0.15	0.23	0.49
	1/15/97	2.7	2.2	**19.3**	2.7	0.11	0.16	0.01	0.42
	4/10/97	-0.14	1.0	**14.2**	2.2	0.11	0.12	0.43	0.44
	7/10/97	0.6	1.6	**13.8**	2.4	0.15	0.20	NA	NA
BS-006PZ	9/17/96	0.1	1.6	10.3	2.5	0.04	0.13	0.29	0.45
	1/14/97	-0.1	1.3	**11.5**	2.0	0.14	0.18	0.14	0.36
	4/10/97	0.1	1.7	10.5	2.1	0.131	0.97	0.07	0.45
	7/10/97	0.4	1.5	10.3	2.3	0.14	0.14	0.19	0.44
MW-02	10/18/96	0.4	1.3	8.8	2.1	0.04	0.15	-0.2	0.43
	12/17/96	3.7	2.0	**12.8**	2.1	0.11	0.16	0.1	0.41
	1/15/97	0.5	1.3	**11.5**	2.0	0.04	0.11	0.07	0.35
	1/15/97 (dup)	0.4	1.2	**11.5**	2.0	0.08	0.13	0.14	0.42
	4/10/97	0.8	1.3	10.8	1.9	0.04	0.14	0.11	0.42
	7/10/97	-0.1	1.3	11.1	2.5	0.11	0.13	0.6	0.42
MW-03	10/18/96	-0.2	1.4	8.3	1.8	0.09	0.17	1.43	0.47
	10/18/96 (dup)	7.8	2.7	8.9	1.8	0.15	0.15	1.88	0.47
	12/17/96	4	2.8	8.9	2.6	0.12	0.17	0.36	0.42
	12/17/96 (dup)	1.8	1.9	9	2.1	0.023	0.10	-0.15	0.40
	1/15/97	-0.2	1.0	8.2	1.8	0.21	0.17	0.12	0.51
	4/10/97	1.4	1.6	**14.8**	2.2	0.13	0.13	0.26	0.44
	7/10/97	0.3	1.7	**17.3**	2.9	0.16	0.15	0.78	0.61
MW-04	10/18/96	10.8	3.9	**17.2**	3.0	0.2	0.17	0.65	0.40
	12/17/96	4.8	2.8	**19.1**	3.1	0.05	0.13	0.09	0.44
	1/14/97	0.3	1.5	**16.4**	2.5	0.1	0.19	-0.19	0.44
	4/10/97	0.2	1.2	**12.9**	2.1	0.11	0.13	0.26	0.37
	7/10/97	-0.67	0.7	11.1	2.1	0.101	0.10	0.15	0.44
MW-05	10/18/96	-0.1	2.1	**12.3**	2.9	0.5	0.26	1.52	0.44
	12/17/96	5.2	3.4	**13.3**	3.2	0.13	0.13	0.35	0.37
	1/14/97	1.9	2.8	10.6	3.0	0.21	0.19	0.03	0.43
	4/10/97	1.3	1.7	8.9	2.0	0.16	0.14	-0.4	0.39
	4/10/97 (dup)	0.3	2.1	7.1	2.3	0.16	0.15	0.01	0.35
	7/10/97	-0.4	1.4	9.9	2.4	0.09	0.11	0.53	0.47
Project Screening Goal		15		11.3		3		2	

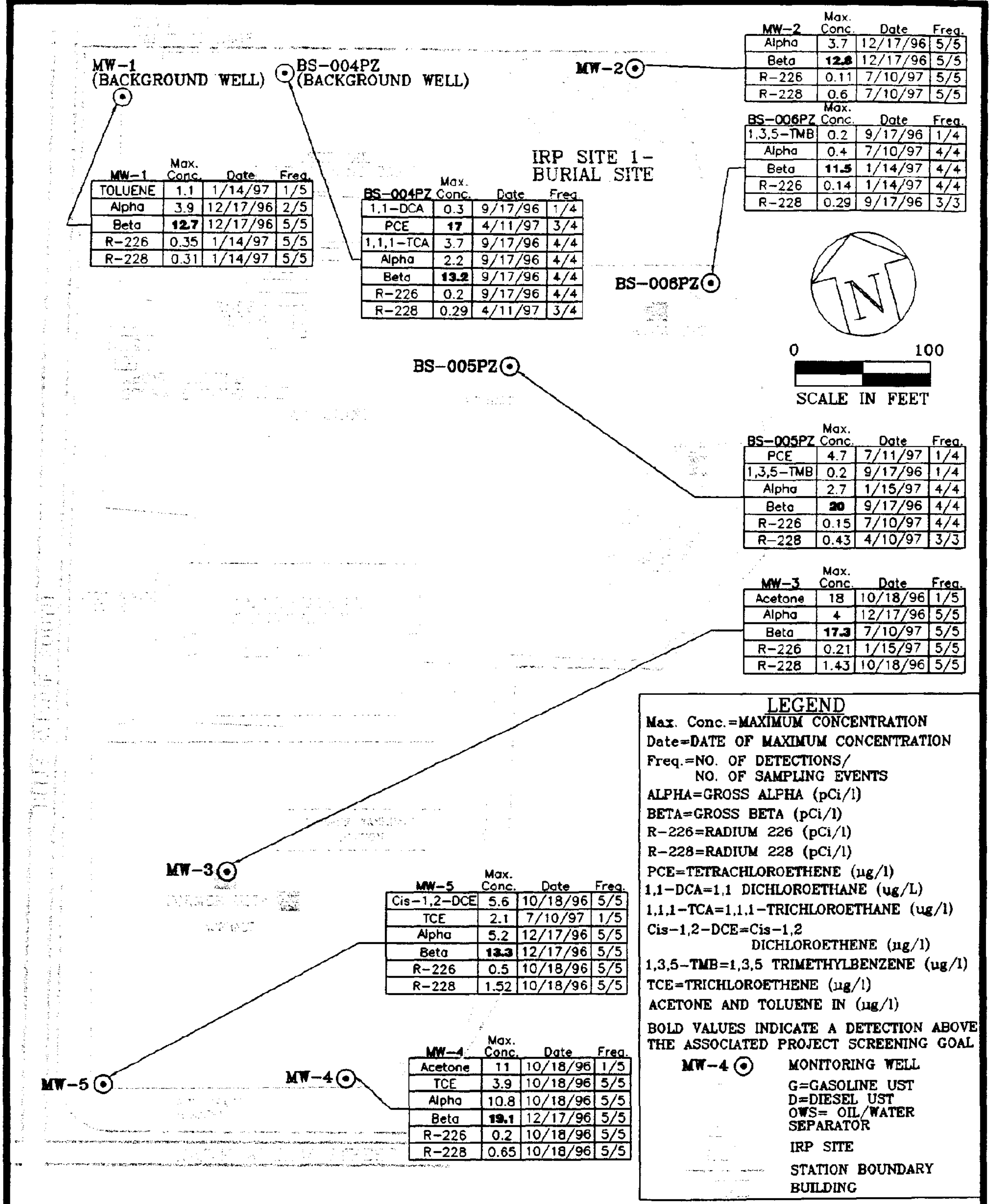
All concentrations in picoCuries per liter (pCi/l)
dup = Duplicate sample
NA = Not analyzed
+/- = Margin of error (pCi/l)
Shaded cells indicate a detection above the associated Project Screening Goal

TABLE 5-13

Trace Metals Detected in Site-Characterization Groundwater Samples Collected from Monitoring Wells
143rd CCSQ, Seattle ANGS, Seattle, Washington

Location	Date	Arsenic	Copper	Nickel	Zinc
BS-005PZ	9/17/96	ND	ND	60	10
	1/15/97	ND	ND	15	(ND)
	4/11/97	ND	ND	9	(ND)
	7/11/97	ND	ND	7	(ND)
BS-006PZ	9/17/96	ND	ND	40	ND
	1/14/97	ND	ND	6	(ND)
	4/11/97	ND	ND	10	(ND)
	7/11/97	ND	8	5	(ND)
MW-02	12/17/96	ND	6	15	(ND)
	1/15/97	ND	10	20	(ND)
	1/15/97 (dup)	ND	11	21	50
	4/10/97	ND	20	16	(ND)
	7/11/97	ND	ND	17	(ND)
MW-03	1/15/97	ND	ND	ND	46
	4/11/97	ND	ND	8	(ND)
	7/11/97	ND	13	ND	(ND)
MW-04	12/17/96	ND	ND	7	(ND)
	1/14/97	ND	ND	7	270
	4/11/97	ND	ND	9	(ND)
MW-05	12/17/96	6	ND	9	(ND)
	1/14/97	ND	ND	10	(ND)
	4/11/97	ND	ND	8	(ND)
	4/11/97 (dup)	ND	ND	7	(ND)
	7/10/97	ND	ND	8	(ND)
	7/10/97 (dup)	ND	ND	8	(ND)
Project Screening Goal		5	1,000	100	5,000

All concentrations in micrograms per liter (µg/l)
dup = Duplicate sample
ND = Not detected above laboratory method reporting limit
(ND) = A positive detection was reported by the laboratory for this compound in the sample indicated. The sample result was qualified as not detected based on a detection of the compound in an associated quality control blank (United States Environmental Protection Agency Contract Laboratory Program "10x" and "5x" rules).
Shaded cells indicate a detection above the associated Project Screening Goal
Note:
Only the results for samples with target analyte detections are shown; samples that were "ND" for all target analytes are not shown.



MW-1	Max. Conc.	Date	Freq.
TOLUENE	1.1	1/14/97	1/5
Alpha	3.9	12/17/96	2/5
Beta	**12.7**	12/17/96	5/5
R-226	0.35	1/14/97	5/5
R-228	0.31	1/14/97	5/5

BS-004PZ	Max. Conc.	Date	Freq.
1,1-DCA	0.3	9/17/96	1/4
PCE	**17**	4/11/97	3/4
1,1,1-TCA	3.7	9/17/96	4/4
Alpha	2.2	9/17/96	4/4
Beta	**13.2**	9/17/96	4/4
R-226	0.2	9/17/96	4/4
R-228	0.29	4/11/97	3/4

MW-2	Max. Conc.	Date	Freq.
Alpha	3.7	12/17/96	5/5
Beta	**12.8**	12/17/96	5/5
R-226	0.11	7/10/97	5/5
R-228	0.6	7/10/97	5/5

BS-006PZ	Max. Conc.	Date	Freq.
1,3,5-TMB	0.2	9/17/96	1/4
Alpha	0.4	7/10/97	4/4
Beta	**11.5**	1/14/97	4/4
R-226	0.14	1/14/97	4/4
R-228	0.29	9/17/96	3/3

BS-005PZ	Max. Conc.	Date	Freq.
PCE	4.7	7/11/97	1/4
1,3,5-TMB	0.2	9/17/96	1/4
Alpha	2.7	1/15/97	4/4
Beta	**20**	9/17/96	4/4
R-226	0.15	7/10/97	4/4
R-228	0.43	4/10/97	3/3

MW-3	Max. Conc.	Date	Freq.
Acetone	18	10/18/96	1/5
Alpha	4	12/17/96	5/5
Beta	**17.3**	7/10/97	5/5
R-226	0.21	1/15/97	5/5
R-228	1.43	10/18/96	5/5

MW-5	Max. Conc.	Date	Freq.
Cis-1,2-DCE	5.6	10/18/96	5/5
TCE	2.1	7/10/97	1/5
Alpha	5.2	12/17/96	5/5
Beta	**13.3**	12/17/96	5/5
R-226	0.5	10/18/96	5/5
R-228	1.52	10/18/96	5/5

MW-4	Max. Conc.	Date	Freq.
Acetone	11	10/18/96	1/5
TCE	3.9	10/18/96	5/5
Alpha	10.8	10/18/96	5/5
Beta	**19.1**	12/17/96	5/5
R-226	0.2	10/18/96	5/5
R-228	0.65	10/18/96	5/5

LEGEND

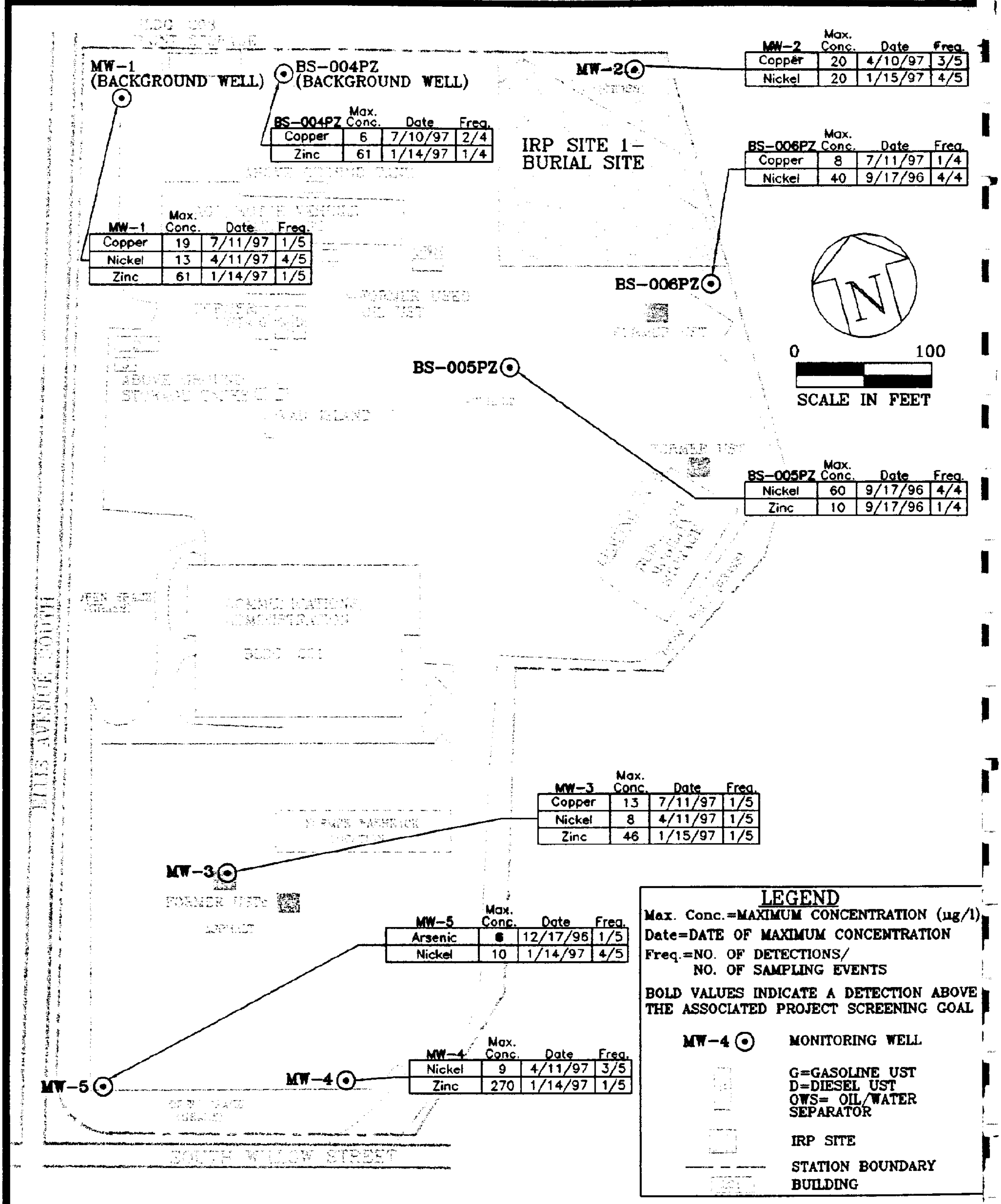
Max. Conc.=MAXIMUM CONCENTRATION
Date=DATE OF MAXIMUM CONCENTRATION
Freq.=NO. OF DETECTIONS/ NO. OF SAMPLING EVENTS
ALPHA=GROSS ALPHA (pCi/l)
BETA=GROSS BETA (pCi/l)
R-226=RADIUM 226 (pCi/l)
R-228=RADIUM 228 (pCi/l)
PCE=TETRACHLOROETHENE (µg/l)
1,1-DCA=1,1 DICHLOROETHANE (ug/L)
1,1,1-TCA=1,1,1-TRICHLOROETHANE (ug/l)
Cis-1,2-DCE=Cis-1,2 DICHLOROETHENE (µg/l)
1,3,5-TMB=1,3,5 TRIMETHYLBENZENE (ug/l)
TCE=TRICHLOROETHENE (µg/l)
ACETONE AND TOLUENE IN (µg/l)
BOLD VALUES INDICATE A DETECTION ABOVE THE ASSOCIATED PROJECT SCREENING GOAL
MW-4 MONITORING WELL
G=GASOLINE UST
D=DIESEL UST
OWS= OIL/WATER SEPARATOR
IRP SITE
STATION BOUNDARY
BUILDING

FIGURE 5-15

MAXIMUM CONCENTRATIONS OF ORGANIC COMPOUNDS AND RADIONUCLIDES DETECTED IN GROUNDWATER SAMPLES
143rd CCSQ, Seattle ANGS
Seattle, Washington

ERM

60325-15.DWG



MW-1	Max. Conc.	Date	Freq.
Copper	19	7/11/97	1/5
Nickel	13	4/11/97	4/5
Zinc	61	1/14/97	1/5

BS-004PZ	Max. Conc.	Date	Freq.
Copper	6	7/10/97	2/4
Zinc	61	1/14/97	1/4

MW-2	Max. Conc.	Date	Freq.
Copper	20	4/10/97	3/5
Nickel	20	1/15/97	4/5

BS-006PZ	Max. Conc.	Date	Freq.
Copper	8	7/11/97	1/4
Nickel	40	9/17/96	4/4

BS-005PZ	Max. Conc.	Date	Freq.
Nickel	60	9/17/96	4/4
Zinc	10	9/17/96	1/4

MW-3	Max. Conc.	Date	Freq.
Copper	13	7/11/97	1/5
Nickel	8	4/11/97	1/5
Zinc	46	1/15/97	1/5

MW-5	Max. Conc.	Date	Freq.
Arsenic	**6**	12/17/96	1/5
Nickel	10	1/14/97	4/5

MW-4	Max. Conc.	Date	Freq.
Nickel	9	4/11/97	3/5
Zinc	270	1/14/97	1/5

FIGURE 5-16

MAXIMUM CONCENTRATIONS OF METALS DETECTED IN GROUNDWATER SAMPLES
143rd CCSQ, Seattle ANGS
Seattle, Washington

ERM

KCSlip4 40700

SEA407230

5.4.6.1 *Volatile Organic Compounds*

VOCs detected in the site-characterization groundwater samples include acetone, cis-1,2-dichloroethene, 1,3,5-trimethylbenzene, PCE, and TCE. None of these VOCs were detected at concentrations above PSGs.

5.4.6.2 *Semivolatile Organic Compounds*

No SVOCs were detected in the site-characterization groundwater samples.

5.4.6.3 *Total Petroleum Hydrocarbons*

No TPH was detected in the site-characterization groundwater samples.

5.4.6.4 *Radionuclides*

Radionuclides were detected in the majority of the site-characterization groundwater samples. Note that the negative concentration values reported on Table 5-12 for some radionuclides are a numerical artifact of the laboratory data reduction methodology for radionuclides. Fifteen detections of gross beta exceed the 95 percent UCL mean background concentration of this constituent. None of the other radionuclides were detected at concentrations exceeding PSGs.

5.4.6.5 *Metals*

Trace metals detected in the site-characterization groundwater samples include arsenic, copper, nickel, and zinc. The single reported detection of arsenic (6 μg/l, in monitoring well MW-5) exceeds the MTCA Method A Cleanup Level. None of the other metals were detected at concentrations exceeding PSGs.

5.5 Field QA/QC Sample Results

Field blank and equipment rinsate blank samples were analyzed for the same parameters as the associated project samples. Trip blanks were analyzed for VOCs only. The analytical results for these QC blank samples are summarized on Table 5-14. Constituents detected in field QC blank samples include phenol, TPH as gasoline, TPH as diesel, gross alpha, gross beta, radium-226, radium-228, mercury, lead, zinc, and 11

TABLE 5-14

Constituents Detected in Field Quality Control Blank Samples
143rd CCSQ, Seattle ANGS, Seattle, Washington

			Volatile Organic Compounds (µg/l)											Metals (µg/l)			Radionuclides (pCi/l)				TPH (µg/l)		SVOCs (µg/l)
Location	Date	Sample Number	ACE	BDCM	CF	MC	P-IPT	PCE	1,2,4-TMB	EB	TOL	m,p-XYL	o-XYL	Mercury	Lead	Zinc	Gross Alpha	Gross Beta	Radium-226	Radium-228	Diesel	Gasoline	Phenol
Field Blank	12/17/96	MW-5-96-1-30*	ND	ND	30	ND	ND	ND	ND	ND	ND	ND	ND	ND	7	6	0.55	2.1	0.25	0.28	ND	ND	14
Field Blank	1/15/97	BS-005PZ-97-1*	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.28	0.7	0.57	0.1	1,000	110	3.1
Field Blank	4/11/97	BS-006PZ-97-2*	ND	70	76	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	42	0.00	0.1	0.06	0.15	ND	ND	ND
Field Blank	7/11/97	BS-006PZ-97-3*	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.19	0.9	0.07	0.98	ND	ND	ND
Pump Rinsate	9/17/96	BS-005PZ-96-1*	6.4	ND	0.3	19	ND	ND	0.8	0.3	1.1	1.2	.5	ND	ND	ND	0.01	0.1	0.13	0.17	ND	ND	ND
Pump Rinsate	10/18/96	MW-4-96-1*	ND	ND	32	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.24	0.15	0.09	0.35	ND	1,200	ND
Pump Rinsate	7/11/97	MW-1-97-3*	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.2	ND	40	0.11	0.01	0.00	0.53	ND	ND	ND
Pump Rinsate	12/17/96	MW-2-96-1-30*	ND	ND	23	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	32	1.52	1.2	0.02	0.23	ND	ND	21
Pump Rinsate	1/15/97	MW-3-97-1*	ND	ND	ND	ND	2.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.07	0.9	0.00	0.00	880	120	ND
Pump Rinsate	4/11/97	MW-1-97-2-2*	ND	57	61	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	51	0.05	1	0.21	0.12	ND	ND	8.6
Trip Blank	9/17/96	TB091796-1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Trip Blank	10/16/97	TB101696	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Trip Blank	10/18/96	TB101896-1	ND	ND	ND	7.7	ND	ND	ND	ND	ND	ND	ND	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Trip Blank	12/17/96	TB-121796-1-30	ND	ND	27	ND	ND	ND	ND	ND	ND	ND	ND	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Trip Blank	1/14/97	TB-011497-1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Trip Blank	1/15/97	TB-011597-1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Trip Blank	4/10/97	TB-041097-2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Trip Blank	4/11/97	TB-041197-2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Trip Blank	7/10/97	TB-071097-1	ND	ND	ND	ND	ND	5.4	ND	ND	ND	ND	ND	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Trip Blank	7/11/97	TB-071197-1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
SS Rinsate	10/15/96	SB-7-9*	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	ND	ND	ND	2	1.6	0.35	0.82	ND	ND	ND
SS Rinsate	10/16/96	SB-10-9*	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	ND	ND	ND	2.4	1.3	0.26	0.24	ND	ND	ND
SS Rinsate	10/17/96	SS-5-0.5*	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	ND	ND	- -

TPH = Total petroleum hydrocarbons
SVOCs = Semivolatile organic compounds
µg/l = micrograms per liter
pCi/l = picoCuries per liter
- - = Sample not analyzed for constituent
ND = Not detected above method reporting limit
SS Rinsate = Split-spoon rinsate

Constituent Abbreviations
ACE = Acetone
BDCM = Bromodichloromethane
CF = Chloroform
MC = Methylene Chloride
P-IPT = p-Isopropyltoluene
PCE = Tetrachloroethene
1,2,4-TMB = 1,2,4-Trimethylbenzene
EB = Ethylbenzene
TOL = Toluene
XYL = Xylenes

VOCs including acetone, methylene chloride, PCE, ethylbenzene, toluene, and xylenes.

In accordance with guidance contained in *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review* (February 1994) and *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* (February 1994), constituents detected in RI background or site-characterization samples that were also detected in any associated QC blank were qualified as not detected if the sample concentration was less than 10 times the blank concentration for common laboratory contaminants, or less than five times the blank concentration for other compounds (USEPA "10x" and "5x" rules). The quantitation limits for constituents qualified as not detected based on the USEPA 10x or 5x rules were elevated to the concentrations found in the affected samples.

5.6 Analytical Data Review and Validation Results

As discussed in Section 4.0, all of the laboratory analytical data generated during the RI were reviewed by a qualified analytical chemist for conformance with the project data quality objectives specified in the RI/FS Work Plan. In addition, approximately ten percent of the analytical data were validated in accordance with *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review* (February 1993) and *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* (February 1994). Appendix J details the scope and results of the analytical data review and validation, and contains the data validation reports for the analytical parameters included in the CLP-like data packages.

Some of the quantitation limits and positive detections reported by the laboratory for selected samples were qualified as estimated values based on the data review and validation. Additionally, less than one percent of the aqueous VOC data were rejected as unusable based on unacceptable instrument calibration verification, and less than two percent of the aqueous SVOC data were rejected based on low surrogate or target compound spike recoveries. The data qualification actions are the result of typical minor analytical accuracy and precision anomalies, and are not considered cause for further action. The project data completeness goal of 90 percent was exceeded for the RI analytical data set. Accordingly, with the exception of the rejected VOC and SVOC data, the validated data are of acceptable quality and can be used for decision-making purposes.

5.7 Summary and Conclusions

This section provides a summary and conclusions regarding the RI sampling results for the Seattle ANGS. The adequacy of the existing RI data for characterizing the IRP site, evaluating compliance with ARARs, and assessing human health risks is also discussed.

5.7.1 Constituents Detected at Background Levels

Constituents detected in soil and groundwater at the Seattle ANGS include VOCs, SVOCs, TPH, radionuclides, and trace metals. Radionuclides and metals were ubiquitous in site-characterization soil samples. The concentrations of radionuclides and metals detected in site-characterization soil samples are consistent with site-specific background concentrations, and soil metals concentrations are also less than or comparable to regional natural background concentrations (WDOE, 1994a). These results suggest that the radionuclides and metals detected in soil at the Seattle ANGS reflect background concentrations. The Head of the WDOE Environmental Radiation Section reviewed the soil radionuclide data for the Station, and likewise concluded that the radioactivity present in the RI soil samples reflects natural background levels. A letter from the WDOE summarizing this finding is included as Appendix H.

The radionuclides and metals detected in RI groundwater samples also appear to reflect background concentrations. The radionuclide concentrations detected in site-characterization samples are comparable to the concentrations in site-specific background samples. Additionally, the radionuclide detections in groundwater are consistent with the presence of naturally occurring radioactive materials in site soils.

With the exception of arsenic, the metals concentrations in site-characterization groundwater samples were also comparable to site-specific background concentrations. Arsenic was detected in only one groundwater sample (collected from monitoring well MW-05) at a concentration of 6 µg/l, slightly above the method reporting limit of 5 µg/l. Arsenic was not detected in any RI background groundwater samples, nor was it detected in any of four prior or subsequent groundwater samples collected from monitoring well MW-05. Because there are no known potential current or historical sources of arsenic at the Station, the single detection of arsenic in groundwater is considered an anomaly.

5.7.2 Suspect Constituent Detections

Only one SVOC was detected during the RI, in a single subsurface soil sample. Bis(2-ethylhexyl)phthalate was detected at a concentration of 3.9 mg/kg in the soil sample collected from 9 feet bgs in soil boring SB-09 (Figure 5-12). Phthalate esters are considered by the USEPA to be common laboratory contaminants (USEPA, 1989). Bis(2-ethylhexyl)phthalate was not detected in any QC blanks associated with the RI samples. However, because bis(2-ethylhexyl)phthalate was detected in only one subsurface soil sample collected within the IRP site, it is suspected that the single reported detection of this compound is due to laboratory contamination.

5.7.3 Contaminants of Potential Concern in Soil

Contaminants of potential concern (COPCs) include any constituents detected above laboratory method reporting limits in site-characterization samples that cannot be attributed to background concentrations or sampling/laboratory contamination. COPCs in soil at the Seattle ANGS include:

- TPH as gasoline, diesel, and heavy oil
- TCE

TPH was detected in five of the ten site-characterization surface soil samples (Figure 5-11). TPH was not detected in subsurface soil. Two RI soil samples were analyzed for VOCs. TCE was detected in the sample collected from 9 feet bgs in the borehole for monitoring well MW-3 (Figure 5-12). Based on water level data for monitoring well MW-3, this soil sample was most likely collected at or below the water table, and the TCE detected in the sample is most likely the result of groundwater impacted by VOCs in this area. None of the COPCs in soil were detected at concentrations above the PSGs shown on Table 5-3.

5.7.4 Contaminants of Potential Concern in Groundwater

COPCs in groundwater at the Seattle ANGS include:

- Benzene
- Toluene
- 1,1,1-trichloroethane
- TCE

- Ethylbenzene
- Xylenes
- cis-1,2-dichloroethene
- 1,2-dichloroethane
- Acetone
- 1,3,5-trimethylbenzene
- PCE

Of these constituents, only cis-1,2-dichloroethene and TCE were detected in more than one site-characterization groundwater sample collected from the monitoring wells (Figure 5-15). With the exception of PCE in background well BS-004PZ, none of the COPCs in groundwater were detected in monitoring wells at concentrations above the PSGs shown on Table 5-4. The concentrations of benzene and TCE detected in Geoprobe/HydroPunch groundwater samples GP-3 and GP-4, respectively, exceed the PSGs for these constituents (Figure 5-10).

5.7.5 Adequacy of Existing Data/Data Gap Evaluation

For the reasons discussed in Section 5.6, the existing data for SVOCs, radionuclides, and metals at the Seattle ANGS are considered adequate for the purposes of the RI. The detections of these compounds in RI samples can be attributed to background concentrations (radionuclides and metals) or suspected laboratory contamination (SVOCs).

TPH was detected in five surface soil samples collected during the RI, at concentrations below PSGs. TPH also was detected in two subsurface soil samples collected during the PA/SI (see Table 2-1). The TPH concentration detected in one of the PA/SI soil samples (780 mg/kg) exceeds the MTCA Method A Cleanup Level. TPH was not detected in any subsurface soil or groundwater samples collected during the RI. The distribution of TPH detected in soil does not display any clear pattern to suggest the possible source(s) of the TPH. With the exception of sampling locations SS-3 (Figure 5-11) and BS-003BH (Figure 2-3), there are no current or historical petroleum storage or dispensing facilities in the areas where TPH was detected. The PA/SI report indicates that an underground storage tank was removed from an area of the Station near sampling location SS-3 in 1983 (OpTech, 1995). The contents of this underground storage tank are unknown.

Based on the shallow depth of the TPH detected in soil (primarily detected in surface soil), the fact that most of the detections cannot be attributed to any nearby potential sources, and the absence of TPH in groundwater, the

TPH detected in surface soil most likely reflects minor surface spills or leaks from lawn mowers, weed trimmers, or other petroleum-powered equipment. Accordingly, the existing data for TPH in surface soil and groundwater at the Seattle ANGS are considered adequate for the purposes of the RI. However, further investigation of subsurface soil proximal to PA/SI soil boring BS-003BH is needed to determine the extent of TPH contamination in this area.

VOCs were detected in at least one groundwater sample collected from seven of the eight monitoring wells at the Seattle ANGS, including two wells used to determine site-specific background concentrations of target constituents (Tables 5-4 and 5-11, Figure 5-15). VOCs were also detected in six Geoprobe/HydroPunch groundwater samples collected at the Station (Table 5-7, Figure 5-10). The distribution of VOCs detected in groundwater does not display any clear pattern to suggest the possible source(s) of the VOCs. Further investigation of soil and groundwater is needed to determine the source and extent of the dissolved VOCs detected in groundwater. In particular, additional soil sampling is needed to determine whether on-site sources of dissolved VOCs are present in soil. The additional soil and groundwater VOC data are necessary to adequately characterize the site, evaluate compliance with ARARs, and assess human health risks.

SECTION 6.0

DISCUSSION OF ARARS

This section provides a preliminary summary of key ARARs that may be relevant to FS development for the Seattle ANGS. ARARs will be further evaluated as necessary during the FS. The following preliminary ARARs have been identified.

6.1 Federal Requirements

6.1.1 Comprehensive Environmental Response, Compensation, and Liability Act

Section 121 (d) of CERCLA, as amended by SARA, addresses the management of Federal facilities. The IRP has been designed to mirror site investigation requirements under CERCLA (i.e., PA, SI, RI, FS, RD, and RA).

6.1.2 Resource Conservation and Recovery Act

Resource Conservation and Recovery Act (RCRA) regulations governing hazardous waste management provide both action- and chemical-specific ARARs that may apply to IRP activities at the Station.

6.1.2.1 Waste Identification

Waste materials generated at the site (e.g., drill cuttings, purge water, decontamination water) are regulated as hazardous waste if they meet the Federal definition provided in 40 Code of Federal Regulations (CFR) 261.

6.1.2.2 Waste Generation and Transport

RI activities or remedial alternatives involving the generation or transport of hazardous waste trigger RCRA hazardous waste generator requirements provided in 40 CFR 262. When hazardous waste is shipped off site in regulated amounts, the manifesting and transport procedures in 40 CFR 263 must be followed.

6.1.2.3 Land Disposal Restrictions

RCRA regulations in 40 CFR 268 set forth Land Disposal Restrictions (also known as Land Ban Requirements) for RCRA wastes. These restrictions were required by the Hazardous and Solid Waste Amendments of 1984 to RCRA to prohibit the continued land disposal of hazardous wastes beyond specified dates. However, wastes treated in accordance with chemical-specific treatment standards provided in 40 CFR 268 Subpart D may be land-disposed as provided therein. The Land Disposal Restrictions potentially affect the storage and disposal of hazardous wastes generated during RI or subsequent remedial activities and may be considered both action- and chemical-specific ARARs.

6.1.2.4 Treatment, Storage, and Disposal Facilities

If remedial alternatives for the site involve the construction or off-site use of RCRA treatment, storage, or disposal (TSD) facilities, regulations provided in 40 CFR 264 become action-specific ARARs. Various subsections of 40 CFR 264 govern standards and procedures for the operation of hazardous waste TSD facilities. For example, a common disposal practice is to create a waste pile of contaminated soil as part of the remediation process. 40 CFR 264 Subpart L promulgates Federal RCRA standards for waste piles, including their design, operating requirements, monitoring and inspection, closure, and post-closure care. Other subparts control tank systems, surface impoundments, land treatment units, landfills, incinerators, and miscellaneous TSD units.

6.1.3 Safe Drinking Water Act

Federal regulations pursuant to the Safe Drinking Water Act (SDWA) govern the quality, usage, and discharge of groundwater as applied to drinking water quality. MCLs specified in 40 CFR 141.11-16 and 141.60-63 are legally enforceable Federal drinking water standards established by the USEPA. Maximum Contaminant Level Goals (MCLGs) specified in 40 CFR 141.50-52 are non-enforceable, health-based goals for drinking water. MCLGs are set at levels at which no adverse health effects may arise. MCLs are set as close as practical to MCLGs. For non-carcinogens, MCLs are nearly always set at the MCLG. The USEPA believes that MCLs are protective of public health; however, it does recognize that specific circumstances may require more stringent standards (i.e., MCLGs) for the protection of public health and the environment.

6.1.4 Clean Water Act

The Federal Clean Water Act and pursuant regulations provide potential location-, chemical-, and action-specific ARARs for IRP activities at the Seattle ANGS.

6.1.4.1 Ambient Water Quality Criteria

The USEPA has promulgated Ambient Water Quality Criteria (AWQC) for surface water and groundwater through 40 CFR 131. Aligned with the Federal Clean Water Act criteria, the standard governing AWQC presents scientific data and guidance on the environmental effects of pollutants, rather than only establishing regulatory requirements. As a result, decision-makers evaluating remedial alternatives may compare their water quality data to Federal data and guidance. Candidate RAs involving contaminated surface water or groundwater must be evaluated within the context of follow-on water usage and the circumstances of the actual or potential release before implementation. AWQC may be considered when evaluating cleanup levels for groundwater or surface water.

6.1.4.2 National Pollutant Discharge Elimination System

National Pollutant Discharge Elimination System (NPDES) regulations govern discharges to surface water and control surface water runoff from storm water discharge systems. Promulgation of Clean Water Act Section 402 and formal ARARs are established for NPDES through 40 CFR 122 and 40 CFR 125, and provide action- and chemical-specific ARARs.

6.1.5 Occupational Safety and Health Act

RI/FS field activities are governed by Occupational Safety and Health Act (OSHA) standards under 29 CFR 1910. Site workers must meet the requirements of the site health and safety plan, possess and use personal protective equipment in accordance with the health and safety plan, and take all precautions to eliminate exposure to unsafe or unhealthy situations. Other applicable OSHA ARARs include health and safety for Federal service contracts (29 CFR 1926) and record keeping and reporting under 29 CFR 1904.

6.1.6 Hazardous Materials Transportation Act

If material containing hazardous wastes is to be transported off site, U.S. Department of Transportation hazardous material transportation requirements in 49 CFR 171-179, pursuant to the Federal Hazardous Materials Transportation Act, may be action-specific ARARs for RI/FS activities. These requirements are supplemental to RCRA transporter requirements in 40 CFR 263.

6.1.7 Clean Air Act

The Federal Clean Air Act may provide action- and chemical-specific ARARs for IRP activities, including subsequent field investigations and RAs such as soil excavation or incineration. All remediation activities must comply with National Primary and Secondary Ambient Air Quality Standards found in 40 CFR 50. Rules governing particulate matter less than 10 microns in size (PM_{10}) are contained in 40 CFR 50, and are important due to the potential detrimental effects of such particles on the lungs. Field activities involving air emissions must ensure compliance with the PM_{10} standard.

6.1.8 Federal Guidance to be Considered

In addition to Federal and State requirements that may be applicable or relevant and appropriate to IRP activities, Federal non-regulatory criteria must be considered. Chemical-specific Federal non-regulatory criteria, used to help characterize risks and to set cleanup goals, include the following:

- USEPA Risk Reference Doses;
- USEPA Health Advisories;
- USEPA Carcinogen Assessment Group Potency Factors;
- USEPA Acceptable Intake Values, Chronic and Subchronic; and
- USEPA guidance manual on water-related fate of 129 priority pollutants.

6.2 State Requirements

6.2.1 Model Toxics Control Act

The State of Washington has a toxic waste cleanup law called the Model Toxics Control Act (MTCA). MTCA is the State equivalent of CERCLA. MTCA outlines cleanup requirements to ensure the protection of human health and the environment while allowing flexibility in site-specific application of these requirements. MTCA defines a two-step approach for establishing cleanup requirements for individual sites. The first step is establishing cleanup standards and the second step is selecting cleanup actions that would best achieve the cleanup standards. The following summary of options for selecting cleanup levels is derived from WDOE (1993).

MTCA provides three options for establishing site-specific cleanup levels. Each of these options uses human health risk as the main determinant in setting cleanup levels.

6.2.1.1 Model Toxics Control Act Method A

MTCA Method A defines cleanup levels for 25 of the most common hazardous substances found at sites (the Method A Tables). These levels were developed using acceptable risk levels outlined in the standards and health-based concentrations included in other applicable State and Federal laws. Method A is designed to be used for cleanups that are relatively straightforward or involve only a few hazardous substances, all of which must be listed on the Method A Tables. The Method A approach is used mainly by small sites that do not warrant the costs of conducting risk assessments and site studies.

6.2.1.2 Model Toxics Control Act Method B

MTCA Method B Cleanup Levels are developed using a site risk assessment that focuses on site characteristics, such as how hazardous substances interact with each other, what the combined health effects may be, and how the substances' movement on- and off-site could threaten human heath and the environment. Applicable State and Federal laws must also be followed.

The lifetime excess cancer risk level for individual carcinogens cannot exceed 1×10^{-6}. If more than one type of hazardous substance is present, the total excess cancer risk level at the site may not exceed 1×10^{-5}. Levels for non-carcinogens cannot exceed the point at which a substance may cause illness in humans. For individual hazardous substances, this point is defined by a "hazard quotient" of 1; for multiple substances, the sum of the individual hazard quotients (i.e., the "hazard index") cannot exceed 1. Natural background concentrations and laboratory testing limitations of a substance also can be considered when setting Method B Cleanup Levels.

Method B is the most common method used for setting cleanup levels when sites are contaminated with substances not listed under Method A.

6.2.1.3 Model Toxics Control Act Method C

MTCA Method C is similar to Method B. The main difference is that the lifetime excess cancer risk is set at 1×10^{-5} for both individual carcinogenic substances and for the total risk caused by all substances on a site. This method may be used when cleanup levels under Method A or B are technically impossible to achieve, lower than background concentrations, or may cause more environmental harm than good. This method may also be applied to qualifying industrial properties. Use of Method C requires proof to WDOE that the cleanup levels will protect human health and the environment.

6.2.2 Hazardous Waste Management Act

The Washington Hazardous Waste Management Act (70.105 Revised Code of Washington) is the State equivalent of RCRA. The regulations that implement the Hazardous Waste Management Act are known as the Dangerous Waste Regulations, Chapter 173-303 WAC. Regulations governing dangerous-waste management in the State of Washington provide both action- and chemical-specific ARARs that may apply to IRP activities at the Station.

6.2.2.1 Waste Identification

Waste materials generated at the site (e.g., drill cuttings, purge water, decontamination water) are regulated as dangerous waste if they meet the State definition provided in WAC 173-303.

6.2.2.2 Waste Generation and Transport

RI activities or remedial alternatives involving the generation or transport of dangerous waste trigger dangerous-waste generator requirements provided in WAC 173-303. When dangerous waste is shipped off site in regulated amounts, the applicable manifesting and transport procedures must be followed.

SECTION 7.0

CONTAMINANT FATE AND TRANSPORT

This section describes the screening of COPCs for further evaluation in the baseline risk assessment presented in Section 8.0, and discusses factors that affect the environmental fate and transport of the selected contaminants.

7.1 Constituent Screening for Baseline Risk Assessment

COPCs detected in soil and groundwater at the Seattle ANGS are summarized in Section 5.6. To focus the assessment of human health risks associated with the COPCs, screening criteria were applied to limit the baseline risk assessment to those constituents that were determined not to comply with regulatory criteria. Constituents found not to comply with regulatory criteria were elevated from COPC status to confirmed contaminants of concern (COCs).

For screening purposes, COPCs detected above PSGs in site-characterization samples were evaluated for compliance with the corresponding numeric ARARs using the MTCA statistical approach detailed in WDOE (1992). This approach requires that the following criteria be met in order to demonstrate compliance with a given numeric ARAR:

1. The 95 percent upper confidence limit (UCL) true mean concentration must be less than the numeric ARAR;

2. No single sample concentration can be greater than two times the numeric ARAR; and

3. Less than ten percent of the sample concentrations can exceed the numeric ARAR.

The sample population for the compliance screening evaluation consisted of the entire RI data set for each matrix sampled (excluding site-specific background samples). Based on WDOE guidance (WDOE, 1992), sample results reported as "not detected" by the laboratory were assigned a value equal to one-half the detection or reporting limit of the analytical method used.

Benzene and TCE in groundwater were the only COPCs detected at concentrations above PSGs in the site-characterization samples. The data values used in the compliance screening evaluation and the relevant summary statistics for these constituents are presented on Table 7-1. The results of the screening evaluation indicate that the concentrations of TCE detected in groundwater do not comply with the MTCA Method A Cleanup Level or the Federal MCL for TCE. The maximum TCE concentration detected in groundwater was 17 µg/l, which is more than twice the MTCA and MCL criterion of 5 µg/l. Based on this result, TCE was elevated from COPC status to a confirmed COC.

The concentrations of benzene detected in groundwater are in compliance with MTCA Method A and Federal MCL criteria based on the statistical screening evaluation. As shown on Table 7-1, the 95 percent UCL mean concentration (1.81 µg/l) is below the MTCA/MCL criterion of 5 µg/l, the maximum concentration (7.6 µg/l) is less than two times the MTCA/MCL criterion, and only two percent of the sample concentrations exceed the MTCA/MCL criterion.

7.2 Physical and Chemical Properties of Contaminants of Concern

TCE in groundwater is the only confirmed COC identified to date at the Seattle ANGS; the existing RI data are not sufficient to identify other COCs from among the COPCs listed in Section 5.6. The primary physical and chemical factors that affect fate and transport of TCE in the environment are its Henry's Law Constant, solubility in water, and organic carbon/water partition coefficient. These factors are described below, along with their relevance to contaminant fate and transport. The numerical values of the physio-chemical factors for TCE are summarized on Table 7-2.

- Henry's Law Constant (H) provides a measure of the tendency of a constituent to volatilize or partition from the aqueous or water phase to the vapor phase. Organic compounds having H values greater than 10^{-3} atmospheres-cubic meters per mole (atm-m^3/mol) tend to volatilize from water. Although organic compounds having H values less than 10^{-3} atm-m^3/mol may volatilize from water, other processes such as adsorption to soil are more likely to influence transport.

TABLE 7-1

Contaminants of Potential Concern Detected Above Project Screening Goals in Groundwater Characterization Samples
143rd CCSQ, Seattle ANGS, Seattle, Washington

Location	Date	Sample Number	Trichloroethene	Benzene
BS-005PZ	9/17/96	BS-005PZ-96-1	0.035	0.01
BS-005PZ	1/15/97	BS-005PZ-97-1	0.5	0.5
BS-005PZ	4/11/97	BS-005PZ-97-2	0.5	0.5
BS-005PZ	7/11/97	BS-005PZ-97-3	0.5	0.5
BS-006PZ	9/17/96	BS-006PZ-96-1	0.035	0.01
BS-006PZ	1/14/97	BS-006PZ-97-1	0.5	0.5
BS-006PZ	4/11/97	BS-006PZ-97-2	0.5	0.5
BS-006PZ	7/11/97	BS-006PZ-97-3	0.5	0.5
GP-01	10/8/96	GP-1	0.5	2.5
GP-02	10/8/96	GP-2	**3.7**	2.5
GP-03	10/8/96	GP-3	0.5	**7.6**
GP-04	10/8/96	GP-4	**17.0**	2.5
GP-05	10/8/96	GP-5	**4.1**	**2.7**
GP-06	10/8/96	GP-6	0.5	2.5
GP-07	10/8/96	GP-7	0.5	2.5
GP-08	10/8/96	GP-8	0.5	2.5
GP-09	10/8/96	GP-9	0.5	2.5
GP-10	10/9/96	GP-10	0.5	2.5
GP-11	10/9/96	GP-11	0.5	2.5
GP-12	10/9/96	GP-12	0.5	2.5
GP-13	10/9/96	GP-13	0.5	2.5
GP-14	10/9/96	GP-14	0.5	2.5
GP-15	10/9/96	GP-15	0.5	2.5
GP-16	10/9/96	GP-16	0.5	2.5
GP-17	10/9/96	GP-17	0.5	2.5
GP-18	10/9/96	GP-18	0.5	2.5
GP-19	10/9/96	GP-19	0.5	2.5
GP-20	10/9/96	GP-20	0.5	2.5
GP-21	10/9/96	GP-21	0.5	2.5
GP-22	10/9/96	GP-22	0.5	2.5
MW-02	10/18/96	MW-2-96-1	0.035	0.01
MW-02	12/17/96	MW-2-96-1-30	0.5	0.5
MW-02	1/15/97	MW-2-97-1	0.5	0.5
MW-02	4/10/97	MW-2-97-2-2	0.5	0.5
MW-02	7/11/97	MW-2-97-3	0.5	0.5
MW-03	10/18/96	MW-3-96-1	0.04	0.01

TABLE 7-1

Contaminants of Potential Concern Detected Above Project Screening Goals in Groundwater Characterization Samples 143rd CCSQ, Seattle ANGS, Seattle, Washington

Location	Date	Sample Number	Trichloroethene	Benzene
MW-03	12/17/96	MW-3-96-1-30	0.5	0.5
MW-03	1/15/97	MW-3-97-1	0.5	0.5
MW-03	4/11/97	MW-3-97-2	0.5	0.5
MW-03	7/11/97	MW-3-97-3	0.5	0.5
MW-04	10/18/96	MW-4-96-1	**3.9**	0.01
MW-04	12/17/96	MW-4-96-1-30	**2.7**	0.5
MW-04	1/14/97	MW-4-97-1	**3.4**	0.5
MW-04	4/11/97	MW-4-97-2	**3.2**	0.5
MW-04	7/11/97	MW-4-97-3	**2.8**	0.5
MW-05	10/18/96	MW-5-96-1	0.04	0.01
MW-05	12/17/96	MW-5-96-1-30	0.5	0.5
MW-05	1/14/97	MW-5-97-1	0.5	0.5
MW-05	4/11/97	MW-5-97-2	0.5	0.5
MW-05	7/10/97	MW-5-97-3	**2.1**	0.5
95% UCL Mean Concentration			1.92	1.81
Maximum Concentration			17.0	7.6
Percentage of Samples with Detections Above PSG/ARAR			2	2
PSG/ARAR			5	5

All concentrations in micrograms per liter (µg/l)
UCL = Upper confidence limit
Shaded cells indicate a positive detection reported by the laboratory; other positive concentrations shown represent one-half the method reporting limit.
PSG = Project Screening Goal (see Table 5-4)
ARAR - Applicable or Relevant and Appropriate Requirement (see Table 5-4)

TABLE 7-2

Physio-chemical Factors for Trichloroethene
143rd CCSQ, Seattle ANGS, Seattle, Washington

Henry's Law Constant (atm-m^3 /mol)	0.0091
Water Solubility (mg/l)	1,100
Organic Carbon/Water Partition Coefficient (Koc) (ml/g)	126

atm-m^3 /mol = Atmospheres-cubic meters per mole
mg/l = Milligrams per liter
ml/g = Milliliters per gram

- Water solubility is an important property affecting compound migration in soil and groundwater. It is expressed in terms of the number of milligrams of a compound that can be dissolved in one liter of water under standard conditions of 25 degrees C and one atmosphere of pressure. The higher the value of solubility, the greater the tendency for a compound to dissolve in water and hence be transported through soil and groundwater.

- The organic carbon/water partition coefficient (Koc) provides an index of the affinity of an organic compound to sorb to organic carbon in soil. Laboratory studies have shown organic forms of carbon present in soil or aquifer material provide adsorption sites for organic compounds. When a compound adsorbs to organic carbon, its movement through soil or groundwater is slowed or retarded. The higher the Koc, the more likely the compound is to adsorb to organic carbon.

7.3 Fate and Transport of Contaminants of Concern

Fate and transport of TCE in groundwater is controlled by its affinity to adsorb to organic carbon-containing particulate matter in the aquifer, the rates of biodegradation and biokinetic decay, and the solubility-based diffusive dilution of the compound in the aquifer.

The primary route of migration for the TCE detected at the Seattle ANGS is transport in groundwater. No hydraulic connection between groundwater at the Seattle ANGS and surface water bodies has been established.

Chemical and biological reactions that can cause degradation of TCE in the environment are discussed in the following sections. Persistence of VOCs such as TCE will vary depending on how the compounds interact with the chemical, physical, and biological properties of the soil/aquifer. Some compounds will dissolve quickly in water, be sorbed less strongly onto soil, and may be more or less susceptible to degradation by chemical or biological action. Thus, the relative concentration of VOCs will vary with time and distance from the source of the VOCs. This effect is called weathering.

7.3.1 Aerobic Processes

Aerobic degradation is a biological process in which bacteria utilize oxygen molecules in a water/soil system to degrade organic compounds. In the aerobic degradation process, the bacteria derive energy from the breakdown reaction, and utilize the organic compound as a source of carbon. The aerobic process typically involves the addition of oxygen and the removal of hydrogen from the organic compound, such that the compound is oxidized.

The results of early laboratory studies indicated that aerobic degradation of chlorinated solvents such as TCE does not occur; however, more recent studies indicate that aerobic degradation of chlorinated solvents can occur, particularly when degrading bacteria are stimulated by the addition of methane and oxygen. However, this aerobic process is not believed to occur under natural conditions.

7.3.2 Anaerobic Processes

Anaerobic processes are those in which organic compounds are degraded by bacteria in the absence of oxygen. Instead of free oxygen, the anaerobic bacteria utilize inorganic, oxygen bearing compounds such as nitrates, sulfates, and carbon dioxide to degrade organic compounds. Studies have reported that under methanogenic conditions, where sulfate is used by bacteria to facilitate degradation, the degradation of TCE can occur via reductive dechlorination.

Reductive dechlorination is a process where bacterial action results in the removal of chlorine atoms from the chlorinated solvent. In anaerobic processes, reductive dechlorination will remove a chlorine atom from TCE resulting in transformation to a dichloroethene (DCE) isomer. Continued reductive dechlorination transforms the DCE isomer to vinyl chloride, and the reductive dechlorination process concludes with the transformation of vinyl chloride to ethene. The DCE isomer and vinyl chloride are referred to as intermediary chemical components of the reductive dechlorination process. Anaerobic degradation of chlorinated solvents was discovered when aquifers were found contaminated with intermediary chemical components which had not historically been used at the overlying sites.

Studies have indicated that during anaerobic degradation, the relative ratios of intermediary chemical components such as DCE and vinyl chloride are dependent upon the level of methanogenic activity of the water/soil system. Under typical environmental conditions, DCE will be more predominant than vinyl chloride. When methanogenic activity is very high, however, vinyl chloride will be the predominant intermediary chemical component.

Various laboratory studies have indicated that 1,1-DCE as well as trans-1,2-DCE and cis-1,2-DCE are formed from TCE during the anaerobic process. Another study determined that only the intermediary chemical component 1,2-DCE is present. It has been suggested that pH plays a role in the specific DCE isomer(s) formed from the reductive dechlorination of TCE.

In summary, while it is known that chlorinated organic compounds will degrade through anaerobic processes, the specific conditions required to initiate and maintain these anaerobic processes are not well understood. The presence of only low concentrations of an organic compound in a water/soil system may not be adequate to stimulate bacterial growth required to initiate the anaerobic process. In addition, certain oxygen sources may be required by degrading bacteria to breakdown specific organic compounds. For example, there is conflicting research regarding the degradability of TCE under denitrifying conditions. Finally, the conditions that affect the rates at which anaerobic processes proceed are not completely quantified. It has been suggested that there is a specific redox potential threshold above which degradation of TCE to vinyl chloride will occur rapidly.

7.3.3 Abiotic Processes

Abiotic processes include strictly chemical and photochemical reactions, and physical processes such as leaching and volatilization. Abiotic processes can be important in the assessment of the degradation characteristics of a water/soil system. TCE can degrade abiotically. TCE may undergo a reductive dehalogenation process to form 1,1-DCE, cis-1,2-DCE or trans-1,2-DCE. However, this is typically a biological degradation reaction and is not a significant abiotic process for TCE.

SECTION 8.0

BASELINE RISK ASSESSMENT

The State of Washington has developed human health risk assessment procedures for use in establishing site-specific cleanup levels for sites impacted by hazardous substances. These procedures were used in a baseline risk assessment to evaluate the potential human health risks associated with the TCE detected in groundwater at the Seattle ANGS. The purpose, methods, and results of the baseline risk assessment are described in this section.

8.1 Purpose of the Baseline Risk Assessment

A baseline risk assessment provides an evaluation of the potential threat to human health posed by COCs at a site in the absence of any RA. If ecological receptors exist, the baseline risk assessment may include an evaluation of potential ecological risks. The baseline risk assessment provides the basis for determining whether or not any RA is necessary and the justification for performing the RA.

The objective of the screening-level baseline risk assessment conducted for the Seattle ANGS was to provide an upper bound on the potential health risks associated with exposure to the observed concentrations of TCE in groundwater. The risk assessment was performed using data generated during the RI. As no ecological receptors were identified during the RI, only human health risks were quantified.

8.2 Identification of Contaminants of Concern

As discussed in Section 7.0, the only confirmed COC identified at the Seattle ANGS based on the existing site-characterization data is TCE in groundwater. Concentrations of TCE detected in groundwater at the Station do not comply with the MTCA Method A Cleanup Level or the Federal MCL of 5 μg/l.

8.3 Human Health Risk Assessment

An assessment of the potential human health risks associated with the observed TCE concentrations in groundwater at the Station was performed according to the exposure and risk characterization procedures and specifications used to derive site-specific MTCA Method B Cleanup Levels (WAC 173-340-720[3]). The health risk assessment consisted of a toxicity assessment, an exposure assessment, and characterization of risks. These components are described separately below.

8.3.1 Toxicity Assessment

The toxicity assessment consists of collecting available data regarding the potential for COCs to cause adverse effects in exposed individuals. These toxicity data are used in conjunction with exposure assumptions derived from the exposure assessment to characterize the associated potential human health risks. The toxicity assessment for the Seattle ANGS relied on existing data published in scientific literature and did not involve the development of new data on toxicity or dose-response relationships. The WDOE publishes an annual update of toxicological data for use in calculating cleanup levels under MTCA. The most recently available update from WDOE and the USEPA Integrated Risk Information System (IRIS) database were used in performing the toxicity assessment for the Seattle ANGS.

Published toxicity factors used in the assessment of human health risks include:

- **USEPA Reference Doses (RfDs).** Oral and inhalation RfDs are USEPA toxicity values for evaluating non-carcinogenic health effects associated with individual compounds. RfDs are used in conjunction with exposure assumptions derived from the exposure assessment to characterize potential non-carcinogenic health risks.

- **Carcinogenic Potency Factors (CPFs).** Oral and inhalation CPFs are USEPA values that characterize the carcinogenic potency of a compound. CPFs are used in conjunction with exposure assumptions to quantify potential carcinogenic health risks. CPFs are expressed in units of kg-day/mg or $(mg/kg/day)^{-1}$, denoting a numerical risk per mg of compound per kg of body weight per day of exposure.

As TCE is a carcinogen, the potential cancer risks associated with exposure to TCE were evaluated in the baseline risk assessment. The CPF for oral exposure (i.e., drinking water ingestion) to TCE is 0.011 kg-day/mg.

8.3.2 Exposure Assessment

This section presents the method used to assess potential human exposures to the TCE detected in groundwater at the Seattle ANGS. The method that was used is based on the MTCA approach for developing site-specific Method B Cleanup Levels for groundwater (WAC 173-340-720[3]). The MTCA approach considers drinking water to be the highest potential beneficial use of groundwater expected to occur under both current and future site-use conditions. The reasonable maximum exposure to hazardous substances is assumed to occur through ingestion of drinking water and inhalation of volatile substances during showering and other domestic water uses. The MTCA approach is thus conservative from the standpoint of estimating exposures for the evaluation of human health risks.

The following equation was used to estimate the carcinogenic exposure dose for TCE:

$$\text{Exposure Dose} = \frac{\text{Concentration (mg/l)} \times \text{INH} \times \text{Ingestion rate (l/day)} \times \text{Exposure duration}}{\text{Avg. body wt. (kg)} \times \text{Lifetime duration}}$$

Exposure dose is expressed in units of mg/kg-day. INH is the inhalation correction factor, which is equal to 2 for volatile organic hazardous substances such as TCE (WAC 173-340-720[7]). In accordance with MTCA (WAC 173-340-720[3][a][ii][B]), the drinking water ingestion rate was assumed to be 2 liters per day, the average body weight was assumed to be 70 kg, the exposure duration was assumed to be 30 years, and the lifetime duration was assumed to be 75 years. The TCE concentration used in calculating exposure dose was the maximum concentration detected in groundwater during the RI (0.017 mg/l, in Geoprobe/HydroPunch sample GP-4).

Using the above equation and assumptions, the calculated carcinogenic exposure dose for TCE is 1.94×10^{-4} mg/kg-day. This calculated exposure dose was used in conjunction with the CPF described in Section 8.3.1 to estimate the numeric cancer risk associated with TCE in groundwater at the Station.

8.3.3 Risk Characterization

Cancer risk is expressed as the incremental probability of a person contracting cancer over a lifetime as a result of exposure to a known or suspected carcinogen. "Incremental" refers to the fact that the cancer risk is in excess of the person's normal risk without this exposure. The estimated excess cancer risk is calculated by multiplying the exposure dose by the CPF:

$$\text{Excess Cancer Risk} = \text{Exposure Dose} \times \text{CPF}$$

The USEPA has an excess cancer risk goal range of 1×10^{-6} to 1×10^{-4} (USEPA, 1989), where an excess cancer risk of 1×10^{-6} is equivalent to one excess incidence of cancer in 1,000,000 people and an excess risk of 1×10^{-4} indicates a risk of one in 10,000. The WDOE upper bound on the acceptable excess cancer risk for individual hazardous substances is 1×10^{-6} (WAC 173-340-705[2][c][ii]).

Using the above equation, the estimated excess cancer risk associated with the maximum TCE concentration detected in groundwater at the Seattle ANGS is 2.14×10^{-6}. This value exceeds the WDOE acceptable cancer risk level of 1×10^{-6}. As discussed in Section 5.7.5, additional soil and groundwater VOC data are needed to adequately characterize the site, evaluate compliance with ARARs, and assess human health risks.

8.4 Uncertainty Analysis

The results of the quantitative human health risk assessment presented in Section 8.3.3 contain various degrees of uncertainty which reflect the uncertainties in the assumptions underlying the risk assessment. Among these are:

- Uncertainty in the laboratory analytical results;
- Uncertainty in the toxicological bases of published toxicity factors (RfDs and CPFs);
- Uncertainty in the exposure assumptions and exposure factor values used in the risk calculations; and
- The cumulative uncertainty in calculated risks resulting from the mathematical manipulation of the above factors.

With the exception of laboratory analytical results, the factors listed above are conservative in nature and typically lead to overestimates of risk. Laboratory analytical results contain uncertainties inherent in various stages of the analytical process. For example, USEPA analytical QA/QC guidelines allow a ±20 percent error in the calibration for metals. If the sample matrix produces interferences, a common occurrence in environmental samples, a 25 percent or greater underestimate or overestimate of the true analyte concentration could occur. The net result of these analytical uncertainties is that analyte concentrations reported by laboratories may contain positive or negative biases of this magnitude.

Unlike the uncertainty in analytical results, the uncertainty associated with toxicological data is usually conservative in nature because the RfDs and CPFs are developed by the USEPA with the intent that even sensitive members of the population will be sufficiently protected. For example, an examination of the USEPA's IRIS database shows that the safety factors used in computing RfDs range from 10 to 10,000.

The CPFs used in risk assessment represent the 95 percent UCL value derived from available published data. This means that actual risks are unlikely to be higher than the potential risks estimated in the baseline risk assessment, but they may be considerably lower. Use of the 95 percent UCL CPF value is consistent with the USEPA and WDOE approach of using reasonable maximum exposure scenarios in estimating risk. Reasonable maximum exposure is defined as the highest exposure that can reasonably be expected to occur at a site. Risk evaluations based on reasonable maximum exposure scenarios are intended to be conservative by characterizing the risks to a maximally exposed receptor. This approach is thus inherently conservative and tends to overestimate risk.

The estimation of cancer and non-cancer risks in the baseline risk assessment followed USEPA and WDOE guidelines. The USEPA and WDOE make use of "default exposure factors" to estimate risks associated with reasonable maximum exposures. As with toxicological data, default exposure factors are used to ensure that potential receptors are adequately protected. The default exposure factors are conservative by design, and thus contribute to the conservative nature of the baseline risk assessment.

SECTION 9.0

CONCLUSIONS

Environmental samples were collected at the Seattle ANGS to characterize soil and groundwater quality at the site. The results of the sample chemical analyses were used to identify COPCs at the site. COPCs include those constituents detected in at least one sample at concentrations that cannot be attributed to background concentrations or sampling/laboratory contamination.

COPCs identified at the Seattle ANGS include:

<u>Soil</u>

- TPH as gasoline, diesel, and heavy oil
- TCE

<u>Groundwater</u>

- Benzene
- Toluene
- Ethylbenzene
- Xylenes
- cis-1,2-dichloroethene
- 1,2-dichloroethane
- 1,1,1-trichloroethane
- TCE
- Acetone
- 1,3,5-trimethylbenzene
- PCE

PSGs derived from State and Federal ARARs were developed for the constituents detected in the RI samples. Benzene and TCE were each detected at concentrations exceeding MTCA Method A Cleanup Levels in two separate Geoprobe/HydroPunch groundwater samples collected in the southern portion of the Station. None of the other COPCs detected in the vicinity of the IRP site or elsewhere at the Station exceeded PSGs.

To focus the assessment of risks associated with the COPCs identified at the Seattle ANGS, COPCs detected above PSGs were screened for compliance with ARARs using MTCA statistical criteria. Benzene and TCE in groundwater are the only COPCs that were detected above PSGs. The observed concentrations of benzene in groundwater were found to comply with the MTCA Method A Cleanup Level for benzene based on the statistical screening evaluation. The observed concentrations of TCE in groundwater were found not to comply with the associated MTCA Method A Cleanup Level.

A screening-level baseline risk assessment was performed to provide an upper bound on the potential human health risks associated with exposure to the observed concentrations of TCE in groundwater at the Station. The health risks were evaluated using the highest TCE concentration detected in groundwater (17 μg/l). The reasonable maximum exposure scenario assumed in the baseline risk assessment was the use of site groundwater for drinking water and other domestic purposes. The estimated excess cancer risk associated with ingestion and inhalation exposures to TCE under this scenario is 2.14×10^{-6}. This value exceeds the WDOE acceptable cancer risk level of 1×10^{-6}.

The distribution of VOCs detected in groundwater at the Station does not display any clear pattern to suggest the possible source(s) of the VOCs. The Paint Storage Building (Building 203; Figure 4-3) may represent a source of the dissolved VOCs detected in background monitoring well BS-004PZ. However, the RI data are insufficient to determine whether Building 203 or a different on- or off-site source may be responsible for the VOCs detected in this and other areas of the site.

Additional soil and groundwater investigation is necessary to determine the source and extent of the dissolved VOCs detected in groundwater at the Seattle ANGS. The additional soil and groundwater data are needed to adequately characterize subsurface VOC concentrations at the Station, evaluate compliance with ARARs, and assess potential human health risks associated with the VOCs.

SECTION 10.0

RECOMMENDATIONS

Based on the results of the environmental sampling and the baseline risk assessment conducted during the RI, further investigation of VOCs in soil and groundwater at the Seattle ANGS is recommended. The investigation should include additional discrete sampling of soil and groundwater in the southern and northwest portions of the Station where VOCs were previously detected in groundwater. The investigation should also include quarterly sampling of the existing groundwater monitoring wells and any new wells installed during the investigation.

The soil and groundwater samples collected during the supplemental investigation should be analyzed for VOCs, and the results evaluated to determine the source and extent of dissolved VOCs in groundwater. The results of the additional sampling should also be used to refine the preliminary estimates of human health risks obtained from the baseline risk assessment.

In addition to the supplemental VOC characterization, further soil sampling in the vicinity of PA/SI soil boring BS-003BH is recommended to determine the extent of TPH contamination that was detected above the MTCA Method A Cleanup Level in this area during the PA/SI.

The additional recommended investigation activities will provide the necessary site characterization for an FS.

SECTION 11.0

REFERENCES

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APPENDIX A

TECHNICAL MEMORANDA FOR FIELD ACTIVITIES

Memorandum

To: Robin Weesner, Mike Arnold

From: Frank Lamphere

Subject: Ground Water Monitoring, Seattle ANGS, September 17, 1996

Date: September 15, 1996

This document outlines the details of ground water sampling on September 17 at the Seattle Air National Guard Station (Seattle ANGS) Seattle, Washington. Ground water samples will be collected from 3 existing monitoring wells at the Seattle ANGS.

Health and Safety Requirements

All personnel are to be familiar with and must follow the Sitewide Safety and Health Plan. This includes using the correct levels of personal protective equipment (PPE). The Site Safety Officer, will ensure that all personnel present during field work fill out the daily tailgate forms.

Ground Water Sampling Procedures

Prior to purging each monitoring well, ground water levels will be measured using an electric water level meter. Ground water level, purging, and sampling information will be entered on ground water monitoring forms.

All monitoring wells located on the base are 2" in diameter. The monitoring wells will be purged and sampled using a portable submersible pump. Prior to sampling, three well volumes will be purged and parameters (pH, conductivity, turbidity, and temperature) will be recorded on ground water monitoring forms.

A field check will be performed to determine if the pre-preserved vials provided by the laboratory contain a sufficient quantity of acid to preserve the samples at the desired pH range (less than 2). The field check will be performed using a ground water sample and pH test paper. After the pH check has been performed the ground water check sample will be discarded.

Purge water will be collected well specific 55-gallon drums. The drums will be labeled and stored on site at a location specified by Seattle ANGS personnel.

Sampling Schedule

The following is a tentative schedule for ground water sampling:

September 17, 1996: BS-004PZ (DUP), BS006PZ, and BS-005PZ (FB)

This schedule may be altered due to site operations, restrictions and/or sampling speed.

FB = Field Blank, ERB = Equipment Rinsate Blank, DUP = Duplicate Sample, CLP = Laboratory Validation Package, and MS/MSD = Matrix Spike/ Matrix Spike Duplicate

Ground Water Sample Identifiers

Sample identifiers for original ground water samples will include the monitoring well number, and the sampling round (this is the first full sampling round of 1996). For example, BS-004PZ-96-1 represents a ground water sample collected during the first round of ground water sampling in 1996 from monitoring well BS-004PZ.

Analytical Parameters

Ground water samples collected from each well will be analyzed for:

- Volatile organic compounds (VOCs) - EPA Methods 5030/8260;
- Semi volatile organic compounds (SVOCs) - EPA Methods 3550/8270;
- Priority Pollutant trace metals - EPA Methods 6010/6020/7470 (filtered and non-filtered)
- Total Petroleum Hydrocarbons (TPH) - State of WA Method WTPH-HCID; and
- Radionuclides - Methods SM-7110A/B, 903.1, 904.0

All ground water analyses except radionuclide will be performed by American Environmental Network (AEN). Radio nuclide analyses will be performed by Lockheed Laboratories (Lockheed). Ground water samples will be shipped daily via Fedex to AEN and Lockheed:

AEN
Att: ________
17400 SW Upper Boones Ferry Rd. Ste. 270
Durham, Oregon
(503) 684-0447
FAX (___) ___-___

Lockheed Laboratories
Att: ________

(___) ___-___
FAX (___) ___-___

NOTE: AEN is paying for sample shipment to their lab.

Quality Assurance/Quality Control (QA/QC) Samples

The following QA/QC samples will be collected. QA/QC samples will be analyzed for the same parameters as original samples.

Duplicate Samples. Field duplicates will be collected at a frequency of 10 % of total number of original samples. A duplicate ground water sample will be collected from monitoring well BS-004PZ. Sample identifiers for field duplicates are the same as the original sample but followed by an asterix (*). Collection time should be the same as original sample.

Trip Blanks. Trip blanks will be collected at the frequency of one per cooler per day. Sample identifiers for trip blanks are as follows: TB-date-#. For example TB091796-1 represents the first trip blank collected on September 17, 1996.

MS/MSD. One MS/MSD will be designated for every 20 ground water samples. MS/MSD will not be requested for any sample collected at the Seattle ANGS.

Field and Equipment Rinsate Blanks. Field and Rinsate blanks will be collected at the frequency of 10% of the number of original samples. A field blank will be collected at monitor well BS-005PZ. Sample identifiers for field and rinsate blanks will be the well identifier at which the blank was prepared followed by an asterix. Collection time should be original sample collection time plus one minute.

Decontamination

All sampling equipment will be decontaminated prior to sampling, between monitoring wells, and after sampling activities have been completed. Decontamination will include the following (in order of performance):

- Hot tap water wash;
- Hot Alconox (or equivalent) and tap water solution wash;
- Tap water rinse;
- Methanol rinse or wipe;
- ASTM Type II water rinse.

All equipment will be allowed to air dry and either wrapped in aluminum foil or positioned to preclude inadvertent contamination prior to reuse.

Required Equipment and Materials

- 2-inch submersible pump, controller, and reel
- Water level meter
- Steel tape
- Photoionization detector (PID)
- pH, conductivity, turbidity, and temperature meters
- ASTM Type II reagent water
- Alconox or Liqui-Nox
- Aluminum foil
- Pesticide grade methanol
- Sampling bottles and coolers

- Ground water monitoring data forms
- Calibration forms
- Chain-of-Custody forms
- Sample labels
- Shipping forms and packaging
- Sitewide Safety and Health Plan
- Visqueen
- 5-gallon buckets (3 to 4)
- Zip lock bags
- Hot water source (hot water heater)
- pH testing paper
- Well lock keys
- Bolt cutters
- 50' of garden hose
- 100' extension cord
- Nitrile gloves
- Half-mask respirator
- 55 gallon drums

Memorandum

To: Robin Weesner, Steve Becker, Mike Arnold

From: Frank Lamphere, ERM-West.

Subject: Remedial Investigation, Seattle ANGS, October 1996

Date: October 14, 1996

This document outlines the details of soil sampling, monitor well installation, and ground water sample collection to be completed during the Remedial Investigation at the Seattle Air National Guard Station (Seattle ANGS), Seattle, Washington. Soil samples will be collected from 11 subsurface soil borings, two storm sewer sediment, and 10 surface soil locations at the Seattle ANGS. Five ground water monitoring wells will be installed and sampled. The locations of the proposed subsurface soil sampling, surface soil sampling, storm sewer sediment sampling, and ground water monitoring wells are shown on attached figures. Optional borehole drilling and soil sampling may be required. The Project/Site Manager will recommend the additional work as optional activities to ANGRC Project Manager, including sample types, locations, and quantities.

The purpose of soil sample collection at 8 of the soil borings is to delineate the horizontal and vertical extent of soil contamination at IRP Site 1-Burial Site (the Site). The remaining three soil borings are for the purpose of establishing background conditions at the Seattle ANGS. The purpose for collecting the 10 surface soil samples is to assess the potential on-Site transport of TPH and radionuclides from off-site locations. Additionally, sediment samples will be collected from two storms sewers located at the Seattle ANGS. The purpose of these samples is to assess the potential for sediments eroded from the site to be transported of off-Station by the storm sewer.

Monitoring wells will be installed for the purpose of defining the lateral extent of ground water contamination downgradient of the Site and for further defining background ground water quality conditions.

Health and Safety Requirements

All personnel are to be familiar with and must follow the Sitewide Safety and Health Plan. This includes using the correct levels of personal protective equipment (PPE). Mike Arnold, the Site Safety Officer, will ensure that all personnel present during fieldwork fill out the daily tailgate forms.

Soil Sampling Procedures

Subsurface Soil Sample Collection

Borehole logging/sampling forms to be used during this investigation are attached to this memo. Once equipment decontamination procedures have been met, continuous drive samples will be collected using a 2-foot split-spoon sampler equipped with brass sampling sleeves.

Continuous drive samples will be collected from the interval between land surface to the target depth. All soil samples will be collected in the unsaturated zone. The thickness of the unsaturated zone will be determined based on geologic conditions and on ground water level measurements conducted at nearby monitoring wells during ground water monitoring activities. It is anticipated that the maximum total depth of the soil borings will be approximately 10 feet below ground surface (bgs).

ANG Site Investigation Protocol requires that two soil samples be collected from each borehole for off-site laboratory analysis. The two samples will be the shallowest and deepest sample at each boring location. An optional third sample will be collected at the intermediate depth if field screening results indicate the presence of organic vapors, elevated TPH, or visual analysis indicates staining.

One sample interval collected from each drive sample will be field-screened for TPH using a TPH field screening kit and for organic vapors using a PID. Three subsurface soil samples collected at the background borings and two subsurface borings at the Site will be designated for laboratory analysis of TPH, SVOCs, PP trace metals (Antimony, Arsenic, Cadmium, Chromium, Lead, Mercury, Nickel, Selenium, Silver, Thallium, Zinc), beryllium, copper, and radionuclides (gross alpha, gross beta, radium-226, and radium-228).

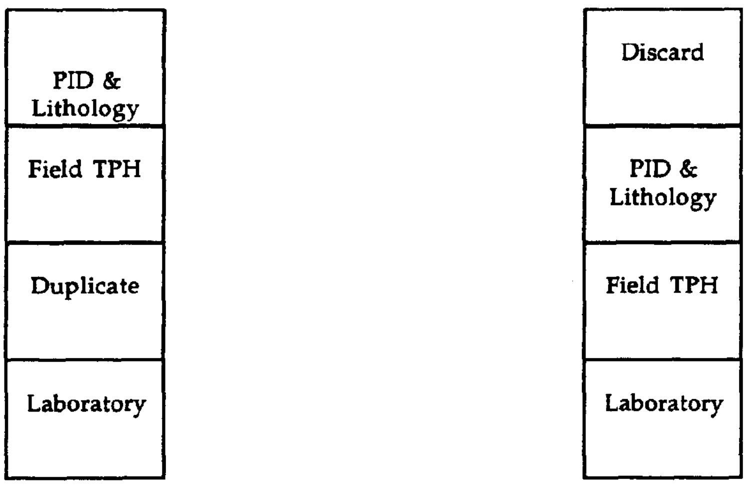
One sample from each intermediate drive sample at each characterization boring will also be held by the laboratory. One optional sample from each boring may then be analyzed for TPH, SVOCs, and VOCs only if field screening indicates the presence of contamination. The sample will be held in the laboratory and analyzed for trace metals only if the upper and lower samples contain significant amounts of trace metals.

The following figure shows the sampling scheme for the drive sampler. From each drive sample, the bottom-most sleeve will be for laboratory analysis, and if applicable, the third sleeve from the top will be submitted as a field duplicate. If no duplicated sample is to be collected, the third sleeve from the top will be used for field screening using the TPH test kits, the second sleeve from the top will be used for litho-logging and for VOC screening using a PID, and the top sleeve will be discarded. If a duplicated sample is to be collected, the second sleeve from the top will be used for screening using the TPH field kit and the top sleeve will be used for litho-logging and for VOC screening using the PID.

Drive Sampler Sampling Scheme

If a Duplicate Sample will be Collected

If no Duplicate Sample will be Collected



The ends of the brass sleeves for soil samples to be sent for laboratory analysis and for field TPH screening will be covered with Teflon, aluminum foil, and with fitted plastic caps. Samples will then be labeled, placed in individual Gladlock bags, and stored on ice. Sample labels provided by the laboratory or ERM will be used for samples to be submitted for laboratory analysis. ERM sample labels will be used for samples to be screened using the field TPH kit.

Surface Soil Sample Collection

Surface soil samples will be collected using a hand auger and a brass sleeve. Samples will be collected from land surface to 6 inches below grade. If the sample location is paved, the sample will be collected to a depth of six inches below the top of the native soil underlying the pavement. All surface soils will be field screened for TPH using the method described in the work plan. All surface soil samples will be submitted for confirmatory analysis of TPH and for radionuclides (gross alpha, gross beta, radium-226, and radium-228). If field screening indicates that TPH concentrations exceed MTCA standards or if visual staining is observed, the samples will also be analyzed for VOCs and SVOCs.

Storm Sewer Sediment Sample Collection

Grab samples of storm sewer sediment will be collected using a trowel or scoop. The samples will be collected in 8-ounce glass jars. The samples will be submitted for laboratory analyses as listed below.

Ground Water Monitor Well Installation

Five ground water monitor wells will be installed using the hollow-stem auger method to a total depth of 20.5 feet below grade surface. Soil samples will be collected at 5-foot intervals and field screened using a PID and TPH test kits. The monitor well construction details are shown on the attached figure. Well construction materials will be decontaminated prior to installation. A performance test will be conducted after the well is completed to ensure the well is straight and has not collapsed. Optional monitor wells may be installed per section 7.1.10.2 in the work plan.

Monitor Well Development

Within 24 to 48 hours after completing, the monitor well will be developed using a submersible pump or a bailer. Water level will be measured before development begins. Temperature, conductivity, turbidity, and pH will be monitored and recorded while a minimum of 10 well volumes and three times the amount of any potable water added are purged from the well. Well development will continue until temperature, pH, turbidity, and conductivity have stabilized and the water is clear and free of sand.

Ground Water Sample Collection

Ground water samples will be collected from all five of the new monitor wells at the Seattle ANGS. The samples will be collected at a minimum of 2 days after the wells have been developed. Ground water samples will be collected and submitted for laboratory analyses as listed below.

Sampling Schedule

The following is a tentative schedule for monitor well installation, borehole drilling, and soil sampling:

October 15, 1996	Soil borings SB-1, SB-2, SB-3, SB-4, SB-5, SB-6, Surface soil SS-1, SS-2, SS-3, SS-4, SS-5,
October 16, 1996	SB-7, SB-8, SB-9, SB-10, SB-11, Surface soil SS-6, SS-7, SS-8, SS-9, SS-10, Storm sewer sediment SW-1 and SW-2;
October 17, 1996:	Install monitor wells MW-1 and MW-2;
October 18, 1996:	Install monitor wells MW-3, MW-4, and MW-5; Develop monitor wells;
November 19, 1996	Sample RI monitor wells collect any remaining surface soil samples.

This schedule may be altered due to site operations and/or sampling speed.

Soil Sample Identifiers

Sample identifiers for original soil samples will include the soil boring number and sample depth. For example, SB-1-6 represents soil boring number one with the sample collected at 6 feet bgs.

Ground Water Sample Identifiers

Sample identifiers for original ground water samples will include the monitor well identifier the sampling round and the year. For example, MW1-1-96 represents a ground water sample collected from monitor well MW-1 during the first sampling round of 1996.

Analytical Parameters

Subsurface soil samples collected from each IRP Site 1- Burial Site boring as well as the back ground boring will be analyzed for:

- PP metals, beryllium, copper using EPA Methods 3050/6010/6020/7470;

- Semi-volatile organic compounds (SVOCs) using EPA Method 3550/8270;
- Total petroleum hydrocarbons (TPH) using WTPH-HCID;
- Radionuclides (gross alpha and Beta, Radium-238 &-238) using Methods SM-7110A/B, 903.1, 904.0.

Surface soil samples will analyzed for:

- *Volatile Organic compounds (VOCs) using EPA Method 5030/8260;
- *Semi-volatile organic compounds (SVOCs) using EPA Method 3550/8270;
- Total petroleum hydrocarbons (TPH) using WTPH-HCID;
- Radionuclides (gross alpha and Beta, Radium-238 &-238) using SM-7110A/B, 903.1, 904.0.

  * samples will be analyzed for VOCs and SVOCs only if field screening indicates concentrations exceed MTCA or if visual staining is present.

Storm sewer sediment samples will be analyzed for:

- PP metals, beryllium, copper using EPA Methods 3050/6010/6020/7470;
- Volatile Organic compounds (VOCs) using EPA Method 5030/8260;
- Semi-volatile organic compounds (SVOCs) using EPA Method 3550/8270;
- Total petroleum hydrocarbons (TPH) using WTPH-HCID;
- Radionuclides (gross alpha and Beta, Radium-238 &-238) using SM-7110A/B, 903.1, 904.0.

Ground water samples will be analyzed for:

- PP metals, beryllium, copper using EPA Methods 6010/6020/7470;
- Volatile Organic compounds (VOCs) using EPA Method 5030/8260;
- Semi-volatile organic compounds (SVOCs) using EPA Method 3550/8270;
- Total petroleum hydrocarbons (TPH) using WTPH-HCID;

- Radionuclides (gross alpha and Beta, Radium-238 &-238) using SM-7110A/B, 903.1, 904.0.

All soil and ground water sample analyses, except radionuclides, will be performed by American Environmental Network (AEN). Radionuclide analyses will be performed by Lockheed Laboratory (Lockheed). Samples will be shipped priority overnight by Federal Express to AEN and Lockheed:

AEN
Att: Sample Receiving
17400 SW Upper Boones Ferry Rd. Suite 270
Durham, OR 97224
(503) 684-0447

Lockheed Analytical Laboratory
Att: Sample Receiving
975 Kelly Johnson Drive
Las Vegas, NV 89119
(800) 582-7605

A validation package will be requested from AEN for selected soil samples collected during one day or for a group of samples listed on one chain-of custody. The particular set of samples designated for validation will be picked in the field. The only constraint is the sample group must contain the MS/MSD designated sample.

Quality Assurance/Quality Control (QA/QC) Samples

The following QA/QC samples will be collected. Duplicate samples will be analyzed for the same parameters as the original samples. Equipment rinsate samples will be analyzed for the same compounds as the original samples. One trip blank per cooler containing VOC samples, made with ASTM Type II water ,will be analyzed for VOCs using EPA Method 5030/8260.

Duplicate Samples. Field duplicates will be collected at a frequency of 10 % of total number of original samples.

Duplicate subsurface soil samples will be collected from the following soil borings:

- SB-9
- SB-6

A duplicate soil samples will be collected from the following surface soil samples:

- SS-1

A duplicate ground water sample will be collected from the following monitor well:

- MW-2

Sample identifiers for field duplicates are the same as the original sample but followed by an asterix (*). Collection time should be the same as original sample.

Trip Blanks. Trip blanks will be collected at the frequency of one per VOC cooler per day. Sample identifiers for trip blanks are as follows: TB-date-#. For example TB101996-1 represents the first trip blank collected on October 19, 1996.

MS/MSD. One MS/MSD will be designated for every 20 soil and every twenty ground water samples.

MS/MSDs will be requested for two field selected subsurface soil samples. One sample from soil borings SB-5, SB-10 will be designated. One surface soil sample will be designated for MS/MSD analysis (SS-2). One ground water sample will be designated for MS/MSD (MW-1).

Extra sample volumes need to be collected for each type of analyses performed. VOC analysis typically requires triple volume, while other analyses require double volume. Confirm MS/MSD volumes with the laboratory prior to sample collection. MS/MSD analyses should be indicated on the Chain-of-Custody form.

Equipment Rinsate and Field Blank. Rinsate blanks from final rinse of drive sampler and submersible pump after decontamination and field blanks will be collected at the frequency of 10% of the number of original samples. Sample identifiers for rinsate blanks and field blanks will be the boring or monitor well identifier at which the blank was prepared followed by an asterix.

One rinsate blank will be collected during collection of back ground subsurface soil samples (SB-3).

One rinsate blank and one field blank will be collected during collection of IRP Site 1 subsurface soil sample collection (SB-8).

One field blank will be collected during subsurface soil sample collection (SB-11)

One field blank will be collected during surface soil sample collection (SS-7).

One rinsate blank will be collected during IRP Site 1 ground water sample collection (MW-3).

One field blank will be collected during IRP Site 1 ground water sample collection (MW-2).

Decontamination

All sampling equipment will be decontaminated prior to sampling, between drive samples, and after sampling activities have been completed. Decontamination will include scrubbing sampling equipment with a laboratory-grade detergent (such as Liqui-Nox or Alconox), followed by a rinse with potable water, a rinse with ASTM Type II reagent water, a pesticide-grade methanol rinse, and a final ASTM Type II reagent water rinse. All equipment will be allowed to air dry, if possible, and either wrapped in aluminum foil or positioned to preclude inadvertent contamination prior to reuse.

The drilling rig and auger flights will be decontaminated after use by steam cleaning.

Sampling Summary

The soil and ground water sampling program are summarized section 6 of the workplan.

Required Equipment and Materials

- Brass sleeves
- Teflon film
- Plastic caps
- Photoionization detector (PID)
- Coolers
- Pesticide grade methanol

- ASTM Type II reagent water
- Alconox or Liqui-Nox
- Aluminum foil
- Borehole logging/sampling record
- Calibration forms
- Chain-of-Custody forms
- Sample labels
- Drum labels
- Sitewide Safety and Health Plan
- Submersible pump, hose, and controllers
- Back-up submersible pump and disposable tubing
- pH/temperature meter
- EC meter
- Turbidity meter
- Water level indicator
- Disposable camera
- Waterproof, bound field notebook
- Water level indicator
- pH paper
- Decontamination buckets and brushes
- Roll of visqueen
- ASTM Type II water machine
- Nitrile gloves
- Tool kit
- TPH field screen kits

- Sample bottles
- Paper towels
- Ziplock bags
- Ice
- Hand scoop/trowel
- Disposable bailers
- Driver sampler

APPENDIX B

BOREHOLE LOGS AND WELL CONSTRUCTION DIAGRAMS

ERM-West, Inc.

ERM

BOREHOLE LOG

Borehole Number SB-1

Page 1 of 1

Project Number: 6032.20

Project Name: Seattle Air National Guard

Location: Seattle, Washington

Contractor: Cascade Drilling

Drilling Method: Hollow Stem Auger

Date(s): 10/15/96

Logged By: M. Arnold

Total Depth: 9.00'

Borehole Dia.: 8.00in

Depth (ft)	Graphic Log	USCS Code	Water Level	Sample Recovery	Blow Counts	Field TPH (mg/kg)	PID (ppm)	Description/Soil Classification
		CC GP ML						
1					5 6 6 7			0.0-0.3' Asphaltic Concrete
2								0.3-0.6' GRAVEL, fine to coarse, subangular, some sand and silt (fill)
3		SP			7 7 8 8	<15	0.1	0.6-2.5' SILT, trace to some fine sand, brown, moist, loose, no odor (fill)
4								
5					6 6 6 6	<15	0.1	
6								2.5-8.5' SAND, fine, none to trace silt, brown, scattered layers (<1/2") silt to silty sand, moist, loose, no odor (fill)
7					4 3 2 2	<15	0.1	
8			▽					
9						<15	0.1	8.5-9.0' SAND, fine, gray, moist, loose, wet below 8.7'
10								Bottom of boring at 9.0 feet
11								
12								
13								
14								
15								
16								
17								
18								
19								

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SEA407281

ERM-West, Inc.
ERM

BOREHOLE LOG

Borehole Number SB-2

Project Number: 6032.20
Project Name: Seattle Air National Guard
Location: Seattle, Washington
Contractor: Cascade Drilling
Drilling Method: Hollow Stem Auger
Date(s): 10/15/96

Logged By: M. Arnold
Total Depth: 11.00'
Borehole Dia.: 8.00in

Depth (ft)	USCS Code	Water Level	Blow Counts	Field TPH (mg/kg)	PID (ppm)	Description/Soil Classification
0–2	ML					0.0-2.0' SILT, trace to some sand, brown, brick fragments (up to 6") 1.0-2.0'
2–4	GP		14 12 7 7			2.0-4.0' GRAVEL, sandy, gray, moist, loose, brick fragments (fill)
4–6	ML		4 6 8 8	>15	0.1	4.0-6.0' SILT, trace fine sand, brown, moist, soft, no odor, scattered layers (~1") of silty sand, (fill)
6–8.5	SM		3 5 6 8	<15	0.1	6.0-8.5' SAND, fine, silty, brown, scattered layers of silt to fine sand (<1"), moist, loose, no odor (fill)
8.5–11	SP	∇ (9.0)	3 5 7 10	<15	0.1	8.5-11.0' SAND, fine, gray, moist, loose, no odor, wet below 9.0'
11				<15	0.1	Bottom of boring at 11.0 feet

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SEA407282

ERM-West, Inc.
ERM

BOREHOLE LOG

Borehole Number
SB-3
Page 1 of 1

Project Number: 6032.20
Project Name: Seattle Air National Guard
Location: Seattle, Washington
Contractor: Cascade Drilling
Drilling Method: Hollow Stem Auger
Date(s): 10/15/96

Logged By: M. Arnold
Total Depth: 9.00'
Borehole Dia.: 8.00in

Depth (ft)	Graphic Log	USCS Code	Water Level	Sample Recovery	Blow Counts	Field TPH (mg/kg)	PID (ppm)	Description/Soil Classification
0–1		ML						
1					5 5 7 9			0.0-3.0' SILT, trace fine sand, brown, moist, soft, no odor (fill)
2								
3		SP			3 3 4 6	>15	0.0	
4								
5					6 8 8 10	>15	0.0	
6								3.0-8.0' SAND, fine, trace to some silt, brown, moist, loose, no odor (fill)
7					5 6 7 8	>15	0.0	
8			▽					
9						>15	0.0	8.0-9.0' SAND, fine, gray, loose, wet
10								Bottom of boring at 9.0 feet
11								
12								
13								
14								
15								
16								
17								
18								
19								

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SEA407283

ERM
ERM-West, Inc.

BOREHOLE LOG

Borehole Number SB-4

Project Number: 6032.20

Project Name: Seattle Air National Guard

Location: Seattle, Washington

Contractor: Cascade Drilling

Drilling Method: Hollow Stem Auger

Date(s): 10/15/966

Logged By: M. Arnold

Total Depth: 9.00'

Borehole Dia.: 8.00in

Depth (ft)	Graphic Log	USCS Code	Water Level	Sample Recovery	Blow Counts	Field TPH (mg/kg)	PID (ppm)	Description/Soil Classification
1		CC GP SM			4 5 6 7			0.0–0.3' Asphaltic Concrete 0.3–0.5' GRAVEL, sandy, fine to coarse, subangular, gray, dry, loose (fill)
2								
3					4 4 7 9	>15	0.0	
4								0.5–6.0' SILT, sandy, brown, scattered layers of silt (~1"), moist, soft, no odor (fill), wood fragments, scattered layers of silty sand to sand below 4'
5					8 6 5 7	>15	0.0	
6		SP						
7					2 2 5 7	>15	0.0	6.0–7.5' SAND, fine, brown, none to trace silt, moist, loose, no odor (fill)
8								7.5–9.0' SAND, fine, gray, none to trace silt, moist, loose, no odor, wet below 8.5'
9						<15	0.0	
10								Bottom of boring at 9.0 feet
11								
12								
13								
14								
15								
16								
17								
18								
19								

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BOREHOLE LOG

Borehole Number SB-5

Project Number: 6032.20

Project Name: Seattle Air National Guard

Location: Seattle, Washington

Contractor: Cascade Drilling

Drilling Method: Hollow Stem Auger

Date(s): 10/15/96

Logged By: M. Arnold

Total Depth: 9.00'

Borehole Dia.: 8.00in

Depth (ft)	USCS Code	Water Level	Blow Counts	Field TPH (mg/kg)	PID (ppm)	Description/Soil Classification
0–0.3	CC					0.0–0.3' Asphaltic Concrete
0.3–0.5	GP					0.3–0.5' GRAVEL, subangular, sandy, gray, fine, dry, loose (fill)
0.5–4.0	ML		4 5 7 8			0.5–4.0' SILT, brown, none to trace fine sand, scattered layers (~1") silty fine sand to fine sand
3			5 5 6 7	>15	0.0	
4.0–8.0	SP					4.0–8.0' SAND, fine, brown, trace silt, moist, loose, no odor (fill)
5			6 8 8 10	<15	0.0	
7			2 2 3 4	<15	0.0	
8.0–9.0		▽ (8.5)				8.0–9.0' SAND, fine, gray, moist, loose, wet below 8.5'
9				<15	0.0	Bottom of boring at 9.0 feet

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BOREHOLE LOG

Borehole Number SB-6

Project Number: 6032.20

Project Name: Seattle Air National Guard

Location: Seattle, Washington

Contractor: Cascade Drilling

Drilling Method: Hollow Stem Auger

Date(s): 10/15/96

Logged By: M. Arnold

Total Depth: 9.00'

Borehole Dia.: 8.00in

Depth (ft)	USCS Code	Water Level	Blow Counts	Field TPH (mg/kg)	PID (ppm)	Description/Soil Classification
0	CC					0.0-0.3' Asphaltic Concrete
	GP					0.3-0.5' GRAVEL, subangular, sandy, fine, gray, dry, loose (fill)
1	ML		4 4 4 6			0.5-3.0' SILT, brown, moist, soft, (fill)
3	SP		4 5 7 9	<15	0.0	3.0-8.0' SAND, fine, brown, moist, loose (fill)
5			8 9 9 16	<15	0.0	
7			2 2 5 9	<15	0.0	
8		▽				8.0-9.0' SAND, fine, gray, moist, loose, wet below 8.8'
9				<15	0.0	Bottom of boring at 9.0 feet

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BOREHOLE LOG

Borehole Number SB-7
Page 1 of 1

Project Number: 6032.20
Project Name: Seattle Air National Guard
Location: Seattle, Washington
Contractor: Cascade Drilling
Drilling Method: Hollow Stem Auger
Date(s): 10/15/96

Logged By: M. Arnold
Total Depth: 9.00'
Borehole Dia.: 8.00in

Depth (ft)	Graphic Log	USCS Code	Water Level	Sample Recovery	Blow Counts	Field TPH (mg/kg)	PID (ppm)	Description/Soil Classification
0		CC GP ML						
1					10 9 8 10			0.0–0.3' Asphaltic Concrete
2								0.3–0.5' GRAVEL, subangular, sandy, fine, gray, dry, loose (fill)
3		SP			4 4 6 8	<15	0.0	0.5–3.0' SILT, brown, none to some fine sand, moist, soft (fill)
4								
5					7 7 5 8	<15	0.0	
6								3.0–8.0' SAND, fine, brown, moist, loose (fill)
7					5 5 6 9	>15	0.0	
8								8.0–9.0' SAND, fine, gray, moist, loose, wet below 8.5'
9						<15	0.0	Bottom of boring at 9.0 feet
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								

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BOREHOLE LOG

Borehole Number SB-8

Project Number: 6032.20

Project Name: Seattle Air National Guard

Location: Seattle, Washington

Contractor: Cascade Drilling

Drilling Method: Hollow Stem Auger

Date(s): 10/16/96

Logged By: M. Arnold

Total Depth: 9.00'

Borehole Dia.: 8.00in

Depth (ft)	Graphic Log	USCS Code	Water Level	Sample Recovery	Blow Counts	Field TPH (mg/kg)	PID (ppm)	Description/Soil Classification
		CC GP SP						
1					13 8 10 12			0.0-0.3' Asphaltic Concrete
2								0.3-0.8' GRAVEL, subangular, sandy, fine, gray to brown, dry to moist, loose (fill)
3					5 9 9 10	>15	0.0	
4								
5					6 7 7 8	>15	0.0	0.8-8.0' SAND, fine, brown, none to trace silt, moist, loose (fill)
6								
7					1 1 2 4	<15	0.0	
8		SM	▽					8.0-9.0' SAND, silty, fine, brown, wet, loose (fill)
9						<15	0.0	Bottom of boring at 9.0 feet
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								

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BOREHOLE LOG

Borehole Number SB-9
Page 1 of 1

Project Number: 6032.20

Project Name: Seattle Air National Guard

Location: Seattle, Washington

Contractor: Cascade Drilling

Drilling Method: Hollow Stem Auger

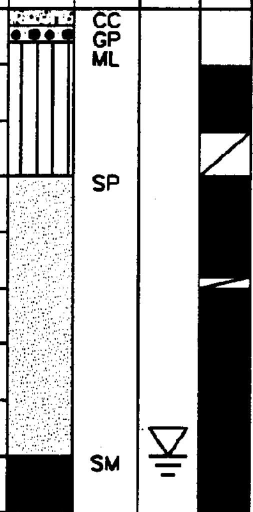
Date(s): 10/16/96

Logged By: M. Arnold

Total Depth: 9.00'

Borehole Dia.: 8.00in

Depth (ft)	Graphic Log	USCS Code	Water Level	Sample Recovery	Blow Counts	Field TPH (mg/kg)	PID (ppm)	Description/Soil Classification
0–1		CC GP ML						0.0–0.3' Asphaltic Concrete
1–2					4 5 4 7			0.3–0.6' GRAVEL, subangular, sandy, fine, gray, dry, loose (fill)
3		SP			6 6 7 10	>15	0.0	0.6–3.0' SILT, brown, trace to some fine sand, moist, soft (fill)
5					4 8 8 9	<15	0.0	3.0–7.0' SAND, fine, brown, scattered layers (~1") of silty sand, moist, loose (fill)
7					12 18 16 12	>15	0.0	7.0–8.0' SAND, fine, gray, wet, loose
8		SM						8.0–9.0' SILT, sandy, gray, soft, wet
9						>15	0.0	Bottom of boring at 9.0 feet



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BOREHOLE LOG

Borehole Number SB-10
Page 1 of 1

Project Number: 6032.20

Project Name: Seattle Air National Guard

Location: Seattle, Washington

Contractor: Cascade Drilling

Drilling Method: Hollow Stem Auger

Date(s): 10/16/96

Logged By: M. Arnold

Total Depth: 9.00'

Borehole Dia.: 8.00in

Depth (ft)	Graphic Log	USCS Code	Water Level	Sample Recovery	Blow Counts	Field TPH (mg/kg)	PID (ppm)	Description/Soil Classification
		CC GP SP						
1					12 21 22 23			0.0–0.3' Asphaltic Concrete
2								0.3–0.8' GRAVEL, subangular, sandy, fine, gray, dry, loose (fill)
3					11 4 5 4	<15 >100	0.0	
4								
5					4 4 5 5	<15	0.0	
6								0.8–8.5' SAND, fine, brown, none to little silt, moist, loose (fill)
7					4 2 2 1	<15	0.0	
8								8.5–9.0' SAND, silty, fine, gray, wet, loose
9		SM				<15	0.0	Bottom of boring at 9.0 feet
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								

KCSlip4 40760

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BOREHOLE LOG

Borehole Number SB-11

Project Number: 6032.20

Project Name: Seattle Air National Guard

Location: Seattle, Washington

Contractor: Cascade Drilling

Drilling Method: Hollow Stem Auger

Date(s): 10/16/96

Logged By: M. Arnold

Total Depth: 9.00'

Borehole Dia.: 8.00in

Depth (ft)	Graphic Log	USCS Code	Water Level	Sample Recovery	Blow Counts	Field TPH (mg/kg)	PID (ppm)	Description/Soil Classification
		CC GP SP						
1					22			0.0–0.3' Asphaltic Concrete
2					16 14 12			0.3–0.6' GRAVEL, subangular, sandy, fine, gray, dry, loose (fill)
3					4	>15	0.0	0.6–3.0' SAND, fine, brown, some silt, moist, loose (fill)
4					4 6 6			
5					5	<15	0.0	
6					5 7 7			3.0–8.0' SAND, fine, brown, moist, loose (fill)
7					6	<15	0.0	
8		SM	▽		10 12 15			8.0–9.0' SAND, silty, fine, gray, wet, loose
9						<15	0.0	Bottom of boring at 9.0 feet
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								

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BOREHOLE LOG

Borehole Number GP-5

Project Number: 6032.20
Project Name: Seattle Air National Guard
Location: Seattle, Washington
Contractor: TEG
Drilling Method: Geoprobe
Date(s): 10/09/96

Logged By: M. Arnold
Total Depth: 10.00'
Borehole Dia.: 0.00in

Depth (ft)	Graphic Log	USCS Code	Water Level	Sample Recovery	Blow Counts	Field TPH (mg/kg)	PID	Description/Soil Classification
		CC						0–0.3' Asphaltic Concrete
		GP						0.3–0.7' Gravel base course
1		ML						0.7–1.5' SILT, brown, soft, moist, fill
2		SM						1.5–4.0' SAND, silty, brown, fine, loose, moist, fill
3								
4		SP						4.0–8.0' SAND, brown, fine, none to trace silt, loose, moist, fill
5								
6								
7								
8		SM						8.0–9.6' SAND, silty, brown, fine, with interbeds of fine SAND (1–3"), loose, moist, fill
9			▼					Wet below 9.0'
		SP						9.6–10.0' SAND, gray, fine, loose, wet
10								Bottom of boring at 10.0'
11								
12								
13								
14								
15								
16								
17								
18								
19								

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BOREHOLE LOG

Borehole Number
GP-10

Project Number: 6032.20

Project Name: Seattle Air National Guard

Location: Seattle, Washington

Contractor: TEG

Drilling Method: Geoprobe

Date(s): 10/09/96

Logged By: M. Arnold

Total Depth: 10.00'

Borehole Dia.: 0.00in

Depth (ft)	Graphic Log	USCS Code	Water Level	Sample Recovery	Blow Counts	Field TPH (mg/kg)	PID	Description/Soil Classification
		CC						0–0.3' Asphaltic Concrete
		GP						0.3–0.5' Gravel base course
1		ML						0.5–3.0' SILT, brown, trace fine sand, soft, moist, fill
2								
3		SM						3.0–9.6' SILT, sandy, to SILT, with trace to some fine sand, soft, moist, fill
4								
5								
6								
7								
8								
9								
		SP						9.6–10.0' SAND, gray, fine, none to trace silt, loose, moist
10								Bottom of boring at 10.0'
11								
12								
13								
14								
15								
16								
17								
18								
19								

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BOREHOLE LOG

Borehole Number GP-13

Project Number: 6032.20

Project Name: Seattle Air National Guard

Location: Seattle, Washington

Contractor: TEG

Drilling Method: Geoprobe

Date(s): 10/09/96

Logged By: M. Arnold

Total Depth: 13.00'

Borehole Dia.: 0.00in

Depth (ft)	Graphic Log	USCS Code	Water Level	Sample Recovery	Blow Counts	Field TPH (mg/kg)	PID	Description/Soil Classification
0–0.3'		CC						Asphaltic Concrete
0.3–0.7'		GP						Gravel base course
0.7–3.8'		ML						SILT, brown, with fine sand, soft, moist, fill
3.8–11.0'		SP						SAND, brown, fine, none to trace silt, loose, moist, fill
11.0–13.0'								SAND, gray, fine, loose, wet

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BOREHOLE LOG

Borehole Number GP-16

Project Number: 6032.20

Project Name: Seattle Air National Guard

Location: Seattle, Washington

Contractor: TEG

Drilling Method: Geoprobe

Date(s): 10/09/96

Logged By: M. Arnold

Total Depth: 10.00'

Borehole Dia.: 0.00in

Depth (ft)	USCS Code	Water Level	Sample Recovery	Blow Counts	Field TPH (mg/kg)	PID	Description/Soil Classification
0–0.3'	CC						0-0.3' Asphaltic Concrete
0.3–0.7'	GP						0.3-0.7' Gravel base course
0.7–1.5'	ML						0.7-1.5' SILT, brown, trace sand, loose, moist, fill
1.5–8.0'	SP						1.5-8.0' SAND, brown, fine, none to trace silt, scattered layers (~1") of silty sand to silt, loose, moist, fill
8.0–9.5'	ML	▼ (9.0')					8.0-9.5' SILT, brown, trace sand and clay, soft, moist Wet below 9.0'
9.5–10.0'	SP						9.5-10.0' SAND, gray, fine, loose, wet Bottom of boring at 10.0'

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SEA407295

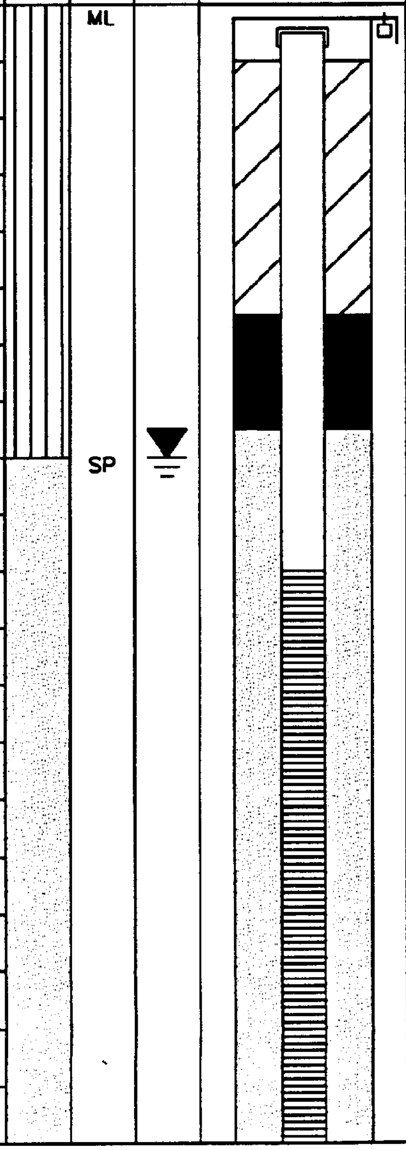
ERM-West, Inc. ERM	# BOREHOLE LOG	Monitoring Well Number MW-1
		Page 1 of 2

Project Number: 6032.20
Project Name: Seattle Air National Guard
Location: Seattle, Washington
Contractor: Cascade Drilling
Drilling Method: Hollow Stem Auger
Logged By: M. Arnold
Date(s): 10/16/96
Total Depth: 21.50'
Completed Depth: 20.50'

Borehole Dia.: 8.00in
Measuring Point: 14.92'

Well Construction				
Blank Casing: type: PVC	dia: 2.00in	fm: 0.5'	to: 10.00'	
Screens: type: Slotted	size: 0.010in	dia: 2.00in	fm: 10.00'	to: 20.00'
Annular Fill: type: Grout			fm: 1.00'	to: 5.50'
type: Bentonite Chips			fm: 5.50'	to: 7.50'
type: Sand Filter			fm: 7.50'	to: 21.50'

Depth (ft)	Graphic Log	USCS Code	Water Level	Well Construction	Sample Recovery	Blow Counts	Field TPH (mg/kg)	PID (ppm)	Description/Soil Classification
0		ML							
1									0.0–8.0' SILT, brown, trace fine sand, moist, soft (fill)
2									
3						4			
4						4 5 6			
5							<15	1.6	
6									
7						4 4			
8		SP	▼			7 10			8.0–21.5' SAND, fine, gray, wet, loose
9							>15	0.0	
10									
11									
12									
13						6 12			
14						14 17			
15								0.0	
16									
17									
18						10 14			
19						21 28		0.0	



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BOREHOLE LOG

Project Number: 6032.20
Project Name: Seattle Air National Guard
Location: Seattle, Washington
Contractor: Cascade Drilling
Drilling Method: Hollow Stem Auger
Logged By: M. Arnold
Date(s): 10/16/96
Total Depth: 21.50'
Completed Depth: 20.50'

Borehole Dia.: 8.00in
Measuring Point: 14.92'

Well Construction			
Blank Casing:			
type: PVC	dia: 2.00in	fm: 0.5'	to: 10.00'
Screens:			
type: Slotted size: 0.010in	dia: 2.00in	fm: 10.00'	to: 20.00'
Annular Fill:			
type: Grout		fm: 1.00'	to: 5.50'
type: Bentonite Chips		fm: 5.50'	to: 7.50'
type: Sand Filter		fm: 7.50'	to: 21.50'

Depth (ft)	Graphic Log	USCS Code	Water Level	Well Construction	Sample Recovery	Blow Counts	Field TPH (mg/kg)	PID (ppm)	Description/Soil Classification
21									
22									Bottom of boring at 21.5 feet
23									
24									
25									
26									
27									
28									
29									
30									
31									
32									
33									
34									
35									
36									
37									
38									
39									

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BOREHOLE LOG

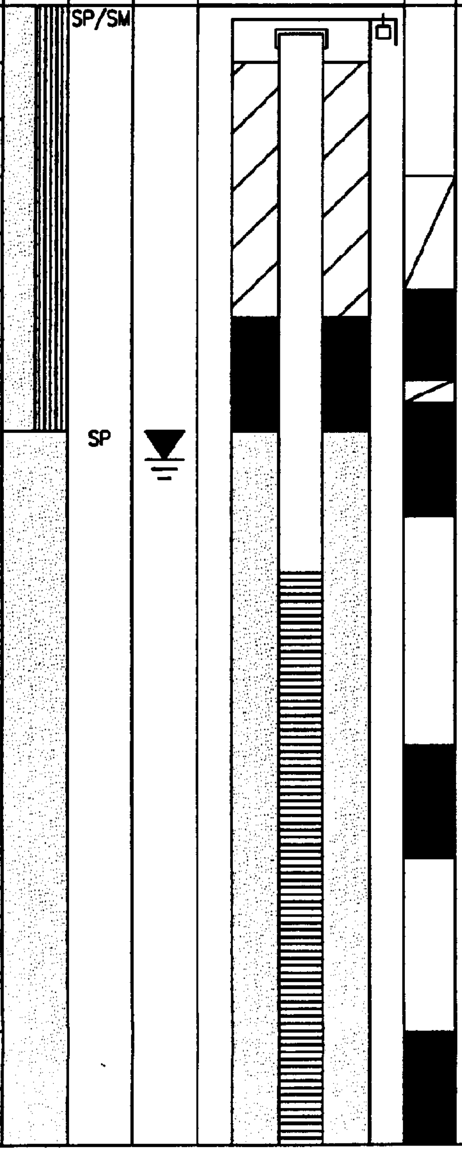
Monitoring Well Number
MW-2

Project Number: 6032.20
Project Name: Seattle Air National Guard
Location: Seattle, Washington
Contractor: Cascade Drilling
Drilling Method: Hollow Stem Auger
Logged By: M. Arnold
Date(s): 10/16/96
Total Depth: 21.50'
Completed Depth: 20.50'

Borehole Dia.: 8.00in
Measuring Point: 14.60'

Well Construction		
Blank Casing: type: PVC dia: 2.00in	fm: 0.5'	to: 10.00'
Screens: type: Slotted size: 0.010in dia: 2.00in	fm: 10.00'	to: 20.00'
Annular Fill: type: Grout	fm: 1.00'	to: 5.50'
type: Bentonite Chips	fm: 5.50'	to: 7.50'
type: Sand Filter	fm: 7.50'	to: 21.50'

Depth (ft)	USCS Code	Water Level	Blow Counts	Field TPH (mg/kg)	PID (ppm)	Description/Soil Classification
0	SP/SM					
1						0.0–7.5' SAND, fine, brown, none to some silt, moist, loose (fill)
3			4 4 7 9			
4						3.0–5.0' No recovery
5			5 8 10 10			
7			2 2 3 3	>15	0.0	
8	SP	▼				7.5–21.5' SAND, fine, gray, moist, loose, wet below 8.0'
9				>15	0.0	
13			10 12 9 15			
18			6 8 16 20			
20					0.0	



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BOREHOLE LOG

Monitoring Well Number
MW-2

Project Number: 6032.20
Project Name: Seattle Air National Guard
Location: Seattle, Washington
Contractor: Cascade Drilling
Drilling Method: Hollow Stem Auger
Logged By: M. Arnold
Date(s): 10/16/96
Total Depth: 21.50'
Completed Depth: 20.50'

Borehole Dia.: 8.00in
Measuring Point: 14.60'

Well Construction				
Blank Casing:				
type: PVC	dia: 2.00in		fm: 0.5'	to: 10.00'
Screens:				
type: Slotted	size: 0.010in	dia: 2.00in	fm: 10.00'	to: 20.00'
Annular Fill:				
type: Grout			fm: 1.00'	to: 5.50'
type: Bentonite Chips			fm: 5.50'	to: 7.50'
type: Sand Filter			fm: 7.50'	to: 21.50'

Depth (ft)	Graphic Log	USCS Code	Water Level	Well Construction	Sample Recovery	Blow Counts	Field TPH (mg/kg)	PID (ppm)	Description/Soil Classification
21									
22									Bottom of boring at 21.5 feet
23									
24									
25									
26									
27									
28									
29									
30									
31									
32									
33									
34									
35									
36									
37									
38									
39									

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BOREHOLE LOG

Project Number: 6032.20
Project Name: Seattle Air National Guard
Location: Seattle, Washington
Contractor: Cascade Drilling
Drilling Method: Hollow Stem Auger
Logged By: M. Arnold
Date(s): 10/17/96
Total Depth: 21.50'
Completed Depth: 20.50'

Borehole Dia.: 8.00in
Measuring Point: 10.50'

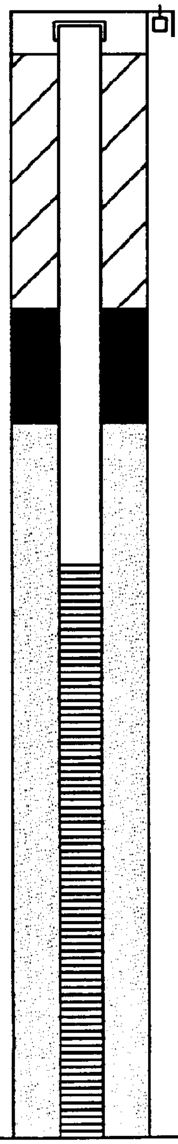
Well Construction

Blank Casing:
type: PVC dia: 2.00in fm: 0.5' to: 10.00'

Screens:
type: Slotted size: 0.010in dia: 2.00in fm: 10.00' to: 20.00'

Annular Fill:
type: Grout fm: 1.00' to: 5.50'
type: Bentonite Chips fm: 5.50' to: 7.50'
type: Sand Filter fm: 7.50' to: 21.50'

Depth (ft)	USCS Code	Water Level	Blow Counts	Field TPH (mg/kg)	PID (ppm)	Description/Soil Classification
0	CC					0.0-0.3' Asphaltic Concrete
0.3	GP					0.3-1.0' GRAVEL, subangular, sandy, fine to coarse, gray to brown, moist, loose (fill)
1	SP					1.0-6.0' SAND, fine, brown, none to trace silt, moist, loose (fill)
3-5			5 5 5 9	>15	0.0	
6	SM					6.0-8.0' SILT, sandy, brown, moist, soft (fill)
7-9		▼ (8)	14 20 30 30	>15	0.0	8.0-10.0' SAND, silty, fine, gray, wet, medium dense
10	SP					10.0-21.5' SAND, fine, gray, wet, medium dense
13-15			8 12 15 18		0.0	
18-20			6 10 14 15		0.0	



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BOREHOLE LOG

Project Number: 6032.20
Project Name: Seattle Air National Guard
Location: Seattle, Washington
Contractor: Cascade Drilling
Drilling Method: Hollow Stem Auger
Logged By: M. Arnold
Date(s): 10/17/96
Total Depth: 21.50'
Completed Depth: 20.50'

Borehole Dia.: 8.00in
Measuring Point: 10.50'

Well Construction				
Blank Casing:				
type: PVC	dia: 2.00in	fm: 0.5'	to: 10.00'	
Screens:				
type: Slotted	size: 0.010in	dia: 2.00in	fm: 10.00'	to: 20.00'
Annular Fill:				
type: Grout			fm: 1.00'	to: 5.50'
type: Bentonite Chips			fm: 5.50'	to: 7.50'
type: Sand Filter			fm: 7.50'	to: 21.50'

Depth (ft)	Graphic Log	USCS Code	Water Level	Well Construction	Sample Recovery	Blow Counts	Field TPH (mg/kg)	PID (ppm)	Description/Soil Classification
21									
22									Bottom of boring at 21.5 feet
23									
24									
25									
26									
27									
28									
29									
30									
31									
32									
33									
34									
35									
36									
37									
38									
39									

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BOREHOLE LOG

Monitoring Well Number
MW-4

Project Number: 6032.20
Project Name: Seattle Air National Guard
Location: Seattle, Washington
Contractor: Cascade Drilling
Drilling Method: Hollow Stem Auger
Logged By: M. Arnold
Date(s): 10/17/96
Total Depth: 21.50'
Completed Depth: 20.50'

Borehole Dia.: 8.00in
Measuring Point: 12.05'

Well Construction

Blank Casing:
type: PVC dia: 2.00in fm: 0.5' to: 10.00'

Screens:
type: Slotted size: 0.010in dia: 2.00in fm: 10.00' to: 20.00'

Annular Fill:

type: Grout	fm: 1.00'	to: 5.50'
type: Bentonite Chips	fm: 5.50'	to: 7.50'
type: Sand Filter	fm: 7.50'	to: 21.50'

Depth (ft)	Graphic Log	USCS Code	Water Level	Well Construction	Sample Recovery	Blow Counts	Field TPH (mg/kg)	PID (ppm)	Description/Soil Classification
0		ML							
1									0.0-9.5' SILT, brown, trace fine sand, moist, soft, (fill), scattered layers
2									
3						5 5 6 7			
4									Scattered layers (~1") of silty fine sand to sand, wet below 9.0'
5							<15		
6									
7						4 4 3 9			
8									
9							<15		Wet below 9.0'
9.5		SP							9.5-21.5' SAND, fine, gray, wet, medium dense
10									
11									
12									
13						12 14 19 22			
14									
15									
16									
17									
18						4 5 5 8			
19									

KCSlip4 40772

SEA407302

ERM-West, Inc.
ERM

BOREHOLE LOG

Project Number: 6032.20
Project Name: Seattle Air National Guard
Location: Seattle, Washington
Contractor: Cascade Drilling
Drilling Method: Hollow Stem Auger
Logged By: M. Arnold
Date(s): 10/17/96
Total Depth: 21.50'
Completed Depth: 20.50'

Borehole Dia.: 8.00in
Measuring Point: 12.05'

Well Construction			
Blank Casing:			
type: PVC	dia: 2.00in	fm: 0.5'	to: 10.00'
Screens:			
type: Slotted size: 0.010in	dia: 2.00in	fm: 10.00'	to: 20.00'
Annular Fill:			
type: Grout		fm: 1.00'	to: 5.50'
type: Bentonite Chips		fm: 5.50'	to: 7.50'
type: Sand Filter		fm: 7.50'	to: 21.50'

Depth (ft)	Graphic Log	USCS Code	Water Level	Well Construction	Sample Recovery	Blow Counts	Field TPH (mg/kg)	PID (ppm)	Description/Soil Classification
21									
22									Bottom of boring at 21.5'
23									
24									
25									
26									
27									
28									
29									
30									
31									
32									
33									
34									
35									
36									
37									
38									
39									

ERM-West, Inc.
ERM

BOREHOLE LOG

Monitoring Well Number
MW-5

Project Number: 6032.20
Project Name: Seattle Air National Guard
Location: Seattle, Washington
Contractor: Cascade Drilling
Drilling Method: Hollow Stem Auger
Logged By: M. Arnold
Date(s): 10/17/96
Total Depth: 21.50'
Completed Depth: 20.50'

Borehole Dia.: 8.00in
Measuring Point: 13.94'

Well Construction			
Blank Casing: type: PVC	dia: 2.00in	fm: 0.5'	to: 10.00'
Screens: type: Slotted size: 0.010in	dia: 2.00in	fm: 10.00'	to: 20.00'
Annular Fill: type: Grout		fm: 1.00'	to: 5.50'
type: Bentonite Chips		fm: 5.50'	to: 7.50'
type: Sand Filter		fm: 7.50'	to: 21.50'

Depth (ft)	Graphic Log	USCS Code	Water Level	Well Construction	Sample Recovery	Blow Counts	Field TPH (mg/kg)	PID (ppm)	Description/Soil Classification
0		ML							
1									0.0-9.0' SILT, brown, trace fine sand, moist, soft, concrete fragments
3						9 9 12 14			SILT, brown, sandy, moist, (fill)
5							<15		
7						6 5 4 4			
8									9.0-21.5' SAND, fine, gray, wet, medium dense
9		SP	▼				>15		
13						10 12 14 17			
18						5 9 12 16			

KCSlip4 40774

SEA407304

ERM-West, Inc.
ERM

BOREHOLE LOG

Project Number: 6032.20
Project Name: Seattle Air National Guard
Location: Seattle, Washington
Contractor: Cascade Drilling
Drilling Method: Hollow Stem Auger
Logged By: M. Arnold
Date(s): 10/17/96
Total Depth: 21.50'
Completed Depth: 20.50'

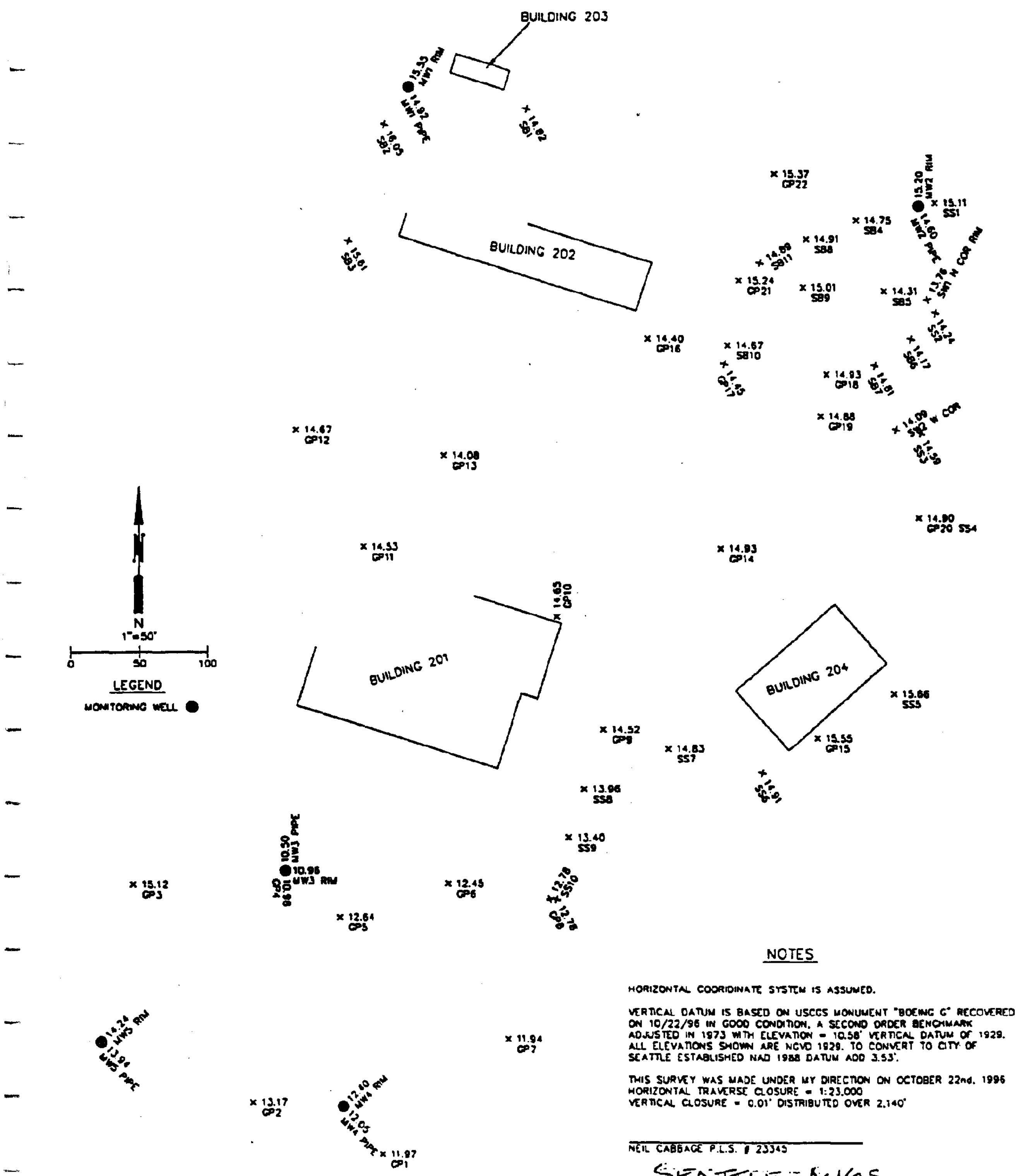
Borehole Dia.: 8.00in
Measuring Point: 13.94'

Well Construction				
Blank Casing:				
type: PVC	dia: 2.00in		fm: 0.5'	to: 10.00'
Screens:				
type: Slotted	size: 0.010in	dia: 2.00in	fm: 10.00'	to: 20.00'
Annular Fill:				
type: Grout			fm: 1.00'	to: 5.50'
type: Bentonite Chips			fm: 5.50'	to: 7.50'
type: Sand Filter			fm: 7.50'	to: 21.50'

Depth (ft)	Graphic Log	USCS Code	Water Level	Well Construction	Sample Recovery	Blow Counts	Field TPH (mg/kg)	PID (ppm)	Description/Soil Classification
21									**Bottom of boring at 21.5 feet**
22									
23									
24									
25									
26									
27									
28									
29									
30									
31									
32									
33									
34									
35									
36									
37									
38									
39									

APPENDIX C

LOCATION AND ELEVATION SURVEY DATA



NOTES

HORIZONTAL COORDINATE SYSTEM IS ASSUMED.

VERTICAL DATUM IS BASED ON USCGS MONUMENT "BOEING C" RECOVERED ON 10/22/96 IN GOOD CONDITION. A SECOND ORDER BENCHMARK ADJUSTED IN 1973 WITH ELEVATION = 10.58' VERTICAL DATUM OF 1929. ALL ELEVATIONS SHOWN ARE NGVD 1929. TO CONVERT TO CITY OF SEATTLE ESTABLISHED NAD 1988 DATUM ADD 3.53'.

THIS SURVEY WAS MADE UNDER MY DIRECTION ON OCTOBER 22nd, 1996
HORIZONTAL TRAVERSE CLOSURE = 1:23,000
VERTICAL CLOSURE = 0.01' DISTRIBUTED OVER 2,140'

NEIL CABBAGE P.L.S. # 23345

SEATTLE ANGS
PLOTTED @ 1"=100'

5/28/97

Landmark Inc., Bellevue, Wa.
1130 140th Ave NE Suite 200
Bellevue, Wa. 98005

ATTN: Steve Becker
ERM-West, Inc
455 Capitol Mall, Suite 800
Sacramento, Calif. 95814

Seattle ANGB survey data collected on 5/27/97:

Well BS005PZ
- 14.74' Ground
- 14.39' top PVC
- 14.80' North rim casing

Well BS006PZ
- 14.78' Ground
- 14.59' top PVC
- 15.07' South rim casing

Well BS004PZ
- 14.88' Asphalt
- 14.66' top PVC
- 15.03' North rim casing

NOTE: Location and elevation of SW-1 and SW-2 requested for this survey was previously obtained and shown on mapping supplied in 1996 (points numbered 147 and 164 in electronic file).

Everett ANGB survey data collected on 5/27/97:

Well ST005PZ
- 599.18' Asphalt
- 598.86' top PVC
- 599.26' North rim casing

Well ST004PZ
- 598.46' Ground
- 598.19' top PVC
- 598.54' North rim casing

Well SDO-005PZ
- 583.29' Asphalt
- 583.00' top PVC
- 583.40' North rim casing

Well SDO-009PZ
- 589.31' Asphalt
- 588.99' top PVC
- 589.35' North rim casing

NEIL SHERMAN CABBAGE
STATE OF WASHINGTON
23345
REGISTERED
PROFESSIONAL LAND SURVEYOR
EXPIRES 2/3/98
5/28/97

KCSlip4 40778

SEA407308

APPENDIX D

INVESTIGATION DERIVED WASTE RECOMMENDATIONS

TABLE D-1

Investigation Derived Waste Recommendations - Soil Matrix
143rd CCSQ, Seattle ANGS, Seattle, Washington

Drum Number/ Contents	Matrix	Collection Date	Recommendation	Comments
1/MW-1	Soil	10/15/96	Dispose of as a solid waste	No analytes from the closest soil borings exceeded the estimated TCLP regulatory levels (1); no PID readings above background levels
2/SB-8, SB-9	Soil	10/16/96	Dispose of as a solid waste	result for TCLP Pb test on sample SB-9-3 was less than the TCLP regulatory level; no PID readings above background levels
3/SB-5, SB-6	Soil	10/15/96	Dispose of as a solid waste	No analytes exceeded estimated TCLP regulatory levels (1); no PID readings above background levels
4/MW-2	Soil	10/16/96	Dispose of as a solid waste	TCLP regulatory levels (1); no PID readings above background levels
5/MW-1, SB-1, SB-2, SB-3	Soil	10/15/96	Dispose of as a solid waste	estimated TCLP regulatory levels (1); for soil borings, no analytes exceeded estimated TCLP regulatory levels (1); no PID readings above background levels
6/SB-4	Soil	10/15/96	Dispose of as a solid waste	result for TCLP Pb test on sample SB-4-3 was less than the TCLP regulatory level; no PID readings above background levels
7/MW-3	Soil	10/17/96	Dispose of as a solid waste	TCLP regulatory levels (1); no PID readings above background levels
8/MW-3	Soil	10/17/96	Dispose of as a solid waste	TCLP regulatory levels (1); no PID readings above background levels
9/SB-10, SB-11	Soil	10/16/96	Dispose of as a solid waste	No analytes exceeded estimated TCLP regulatory levels (1); no PID readings above background levels
10/SB-7, SB-8	Soil	10/16/96	Dispose of as a solid waste	No analytes exceeded estimated TCLP regulatory levels (1); no PID readings above background levels
11/MW-4, MW-5	Soil	10/17/96	Dispose of as a solid waste	TCLP regulatory levels (1); no PID readings above background levels
12/MW-4, MW-5	Soil	10/17/96	Dispose of as a solid waste	TCLP regulatory levels (1); no PID readings above background levels

Notes:

Radionuclides in soil determined to be present at background levels based on a review of the data by the Washington Department of Health - Division of Radiation Protection

(1) = Estimated TCLP regulatory levels - analyte concentrations in soil were compared to 20 times the TCLP regulatory level, which represents an estimate of the minimum concentration of the analyte that would have to be present in the soil for a concentration greater than the TCLP regulatory standard

MW = Monitoring well

PID = Photoionization detector; used for field screening soil samples for the presence of volatile organic compounds

SB = Soil boring

TCLP = Toxicity Characteristic Leaching Procedure (Federal Title 40 Part 261.24)

TABLE D-2

Investigation Derived Waste Recommendations - Water Matrix
143rd CCSQ, Seattle ANGS, Seattle, Washington

Well Location	Matrix	Collection Date	Recommendation	Comments
BS-004PZ	Purge Water and Decon. Water	Sep-96	Discharge to Sanitary Sewer (on-site)	Discharge approved by KCIW/DOH
BS-005PZ	Purge Water and Decon. Water	Sep-96	Discharge to Sanitary Sewer (on-site)	Discharge approved by KCIW/DOH
BS-006PZ	Purge Water and Decon. Water	Sep-96	Discharge to Sanitary Sewer (on-site)	Discharge approved by KCIW/DOH
MW-1	Water and Purge Water	Oct-96	Discharge to Sanitary Sewer (on-site)	Discharge approved by KCIW/DOH
MW-2	Water and Purge Water	Oct-96	Discharge to Sanitary Sewer (on-site)	Discharge approved by KCIW/DOH
MW-3	Water and Purge Water	Oct-96	Discharge to Sanitary Sewer (on-site)	Discharge approved by KCIW/DOH
MW-4	Water and Purge Water	Oct-96	Discharge to Sanitary Sewer (on-site)	Discharge approved by KCIW/DOH
MW-5	Water and Purge Water	Oct-96	Discharge to Sanitary Sewer (on-site)	Discharge approved by KCIW/DOH
Decon. Water	Decon. Water	Oct-96	Discharge to Sanitary Sewer (on-site)	Discharge approved by KCIW/DOH
MW-1	Purge Water and Decon. Water	Dec-96	Discharge to Sanitary Sewer (on-site)	Discharge approved by KCIW/DOH
MW-2	Purge Water and Decon. Water	Dec-96	Discharge to Sanitary Sewer (on-site)	Discharge approved by KCIW/DOH
MW-3	Purge Water and Decon. Water	Dec-96	Discharge to Sanitary Sewer (on-site)	Discharge approved by KCIW/DOH
MW-4	Purge Water and Decon. Water	Dec-96	Discharge to Sanitary Sewer (on-site)	Discharge approved by KCIW/DOH
MW-5	Purge Water and Decon. Water	Dec-96	Discharge to Sanitary Sewer (on-site)	Discharge approved by KCIW/DOH
Decon. Water	Decon. Water	Dec-96	Discharge to Sanitary Sewer (on-site)	Discharge approved by KCIW/DOH
MW-1	Purge Water and Decon. Water	Jan-97	Discharge to Sanitary Sewer (on-site)	Discharge approved by KCIW/DOH
MW-2	Purge Water and Decon. Water	Jan-97	Discharge to Sanitary Sewer (on-site)	Discharge approved by KCIW/DOH
MW-3	Purge Water and Decon. Water	Jan-97	Discharge to Sanitary Sewer (on-site)	Discharge approved by KCIW/DOH
MW-4	Purge Water and Decon. Water	Jan-97	Discharge to Sanitary Sewer (on-site)	Discharge approved by KCIW/DOH
MW-5	Purge Water and Decon. Water	Jan-97	Discharge to Sanitary Sewer (on-site)	Discharge approved by KCIW/DOH

TABLE D-2

Investigation Derived Waste Recommendations - Water Matrix
143rd CCSQ, Seattle ANGS, Seattle, Washington

Well Location	Matrix	Collection Date	Recommendation	Comments
BS-004PZ	Purge Water and Decon. Water	Jan-97	Discharge to Sanitary Sewer (on-site)	Discharge approved by KCIW/DOH
BS-005PZ	Purge Water and Decon. Water	Jan-97	Discharge to Sanitary Sewer (on-site)	Discharge approved by KCIW/DOH
BS-006PZ	Purge Water and Decon. Water	Jan-97	Discharge to Sanitary Sewer (on-site)	Discharge approved by KCIW/DOH
Decon. Water	Decon. Water	Jan-97	Discharge to Sanitary Sewer (on-site)	Discharge approved by KCIW/DOH
MW-1	Purge Water and Decon. Water	Jul-97	Discharge to Sanitary Sewer (on-site)	Discharge approved by KCIW/DOH
MW-2	Purge Water and Decon. Water	Jul-97	Discharge to Sanitary Sewer (on-site)	Discharge approved by KCIW/DOH
MW-3	Purge Water and Decon. Water	Jul-97	Discharge to Sanitary Sewer (on-site)	Discharge approved by KCIW/DOH
MW-4	Purge Water and Decon. Water	Jul-97	Discharge to Sanitary Sewer (on-site)	Discharge approved by KCIW/DOH
MW-5	Purge Water and Decon. Water	Jul-97	Discharge to Sanitary Sewer (on-site)	Discharge approved by KCIW/DOH
BS-004PZ	Purge Water and Decon. Water	Jul-97	Discharge to Sanitary Sewer (on-site)	Discharge approved by KCIW/DOH
BS-005PZ	Purge Water and Decon. Water	Jul-97	Discharge to Sanitary Sewer (on-site)	Discharge approved by KCIW/DOH
BS-006PZ	Purge Water and Decon. Water	Jul-97	Discharge to Sanitary Sewer (on-site)	Discharge approved by KCIW/DOH
Decon. Water	Decon. Water	Jul-97	Discharge to Sanitary Sewer (on-site)	Discharge approved by KCIW/DOH

Notes:

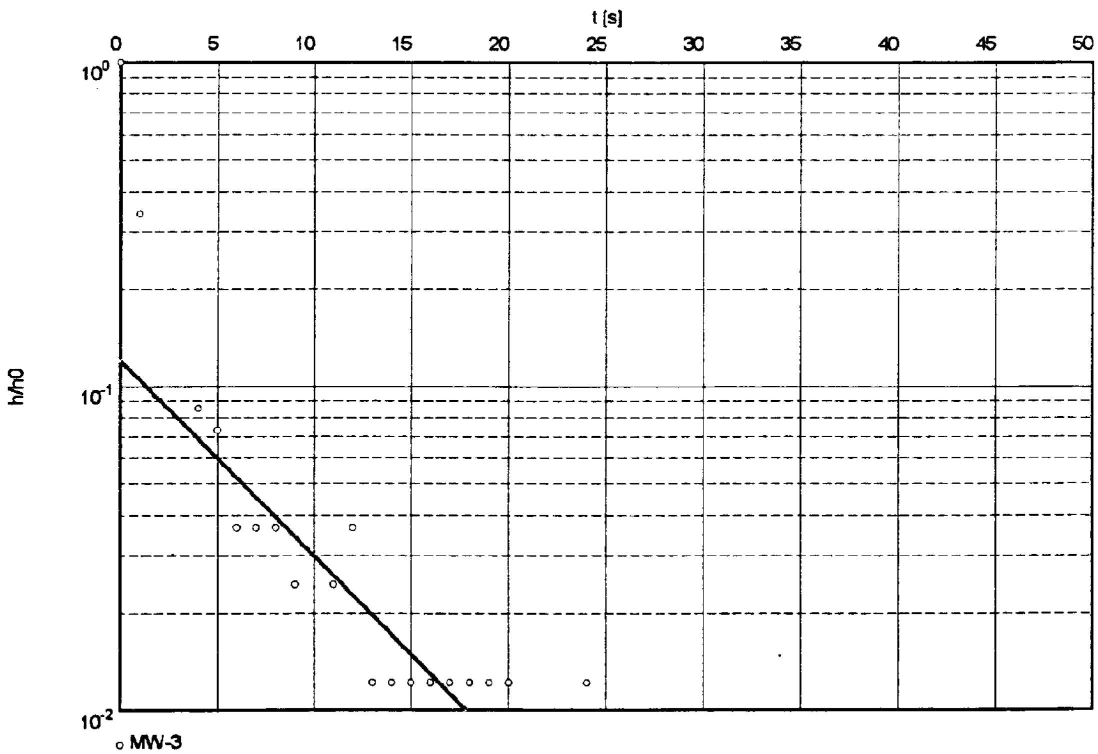
KCIW = King County Industrial Waste Division
DOH = Department of Health, Division of Radiation Protection
Decon. = Decontamination

APPENDIX E

AQUIFER TEST DATA

ERM-West, Inc. 455 Capitol Mall, Suite 800 Sacramento, CA 95814 ph.(916)444-9378	slug/bail test analysis BOUWER-RICE's method	Page 1 Project: Seattle ANGS RI Evaluated by: fjl Date: 9/24/97

Slug Test No. Slug In #1	Test conducted on: 5/2/97
MW-3	



Hydraulic conductivity [ft/s]: 1.41×10^{-4}

KCSlip4 40784

SEA407314

ERM-West. Inc. 455 Capitol Mall, Suite 800 Sacramento, CA 95814 ph (916)444-9378	slug/bail test analysis BOUWER-RICE's method	Page 2	
		Project: Seattle ANGS RI	
		Evaluated by: fjl	Date: 9/24/97

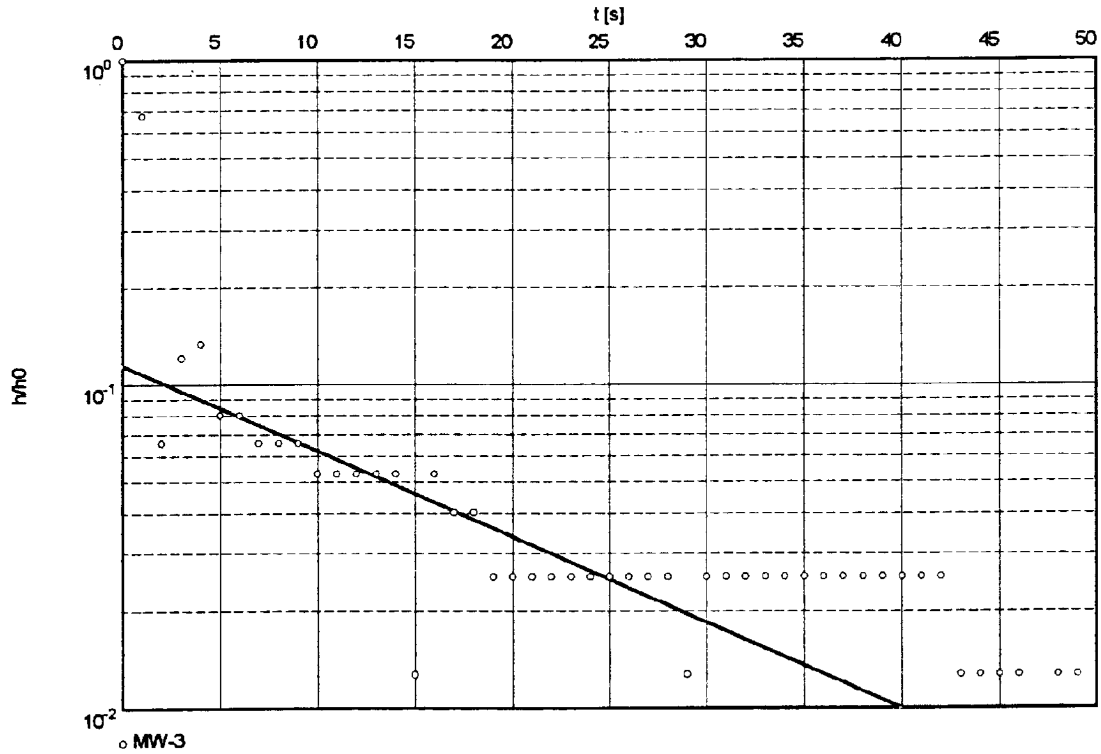
Slug Test No. Slug In #1	Test conducted on: 5/2/97
MW-3	MW-3

Static water level: 6.16 ft below datum

	Pumping test duration [s]	Water level [ft]	Drawdown [ft]	
1	0	5.34	-0.82	
2	1	5.88	-0.28	
3	4	6.09	-0.07	
4	5	6.10	-0.06	
5	6	6.13	-0.03	
6	7	6.13	-0.03	
7	8	6.13	-0.03	
8	9	6.14	-0.02	
9	11	6.14	-0.02	
10	12	6.13	-0.03	
11	13	6.15	-0.01	
12	14	6.15	-0.01	
13	15	6.15	-0.01	
14	16	6.15	-0.01	
15	17	6.15	-0.01	
16	18	6.15	-0.01	
17	19	6.15	-0.01	
18	20	6.15	-0.01	
19	21	6.16	0.00	
20	22	6.16	0.00	
21	23	6.16	0.00	
22	24	6.15	-0.01	
23	25	6.16	0.00	
24	26	6.16	0.00	
25	27	6.16	0.00	
26	28	6.16	0.00	
27	29	6.16	0.00	
28	31	6.16	0.00	

ERM-West. Inc. 455 Capitol Mall, Suite 800 Sacramento, CA 95814 ph.(916)444-9378	slug/bail test analysis BOUWER-RICE's method	Page 1	
		Project: Seattle ANGS RI	
		Evaluated by: fjl	Date: 9/24/97

Slug Test No. Slug Out #1	Test conducted on: 5/2/97
MW-3	



Hydraulic conductivity [ft/s]: 3.10×10^{-4}

KCSlip4 40786

SEA407316

ERM-West. Inc. 455 Capitol Mall, Suite 800 Sacramento, CA 95814 ph.(916)444-9378	slug/bail test analysis BOUWER-RICE's method	Page 2
		Project: Seattle ANGS RI
		Evaluated by: fjl — Date: 9/24/97

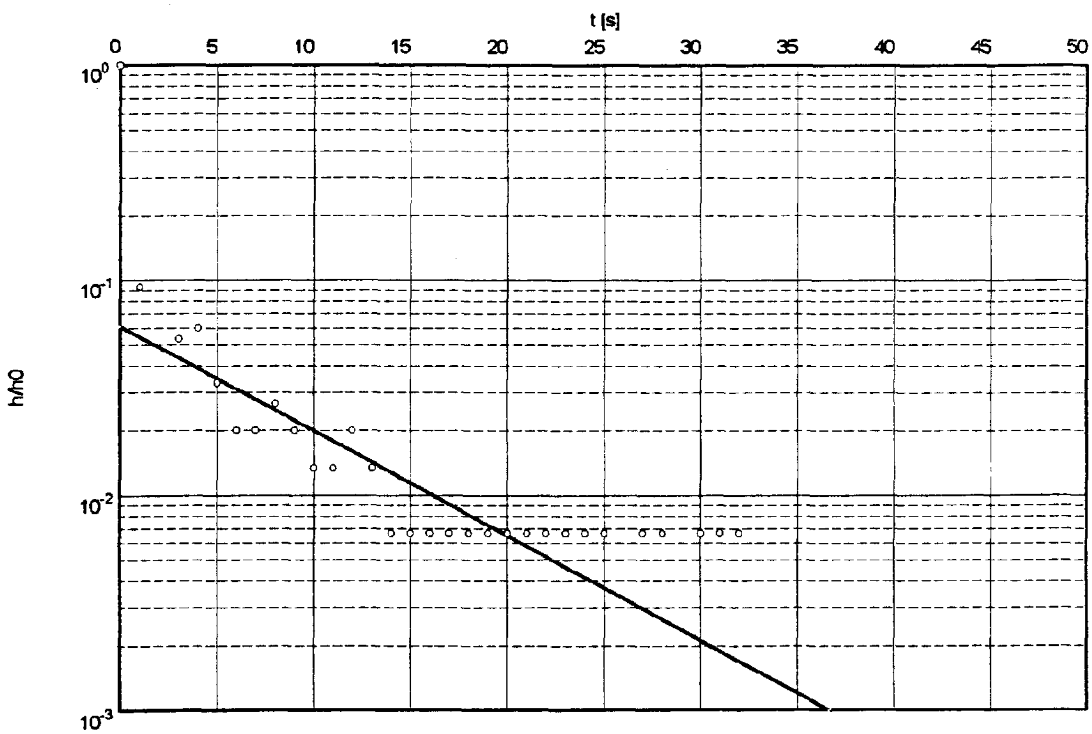
Slug Test No. Slug Out #1	Test conducted on: 5/2/97
MW-3	MW-3

Static water level: 6.16 ft below datum

	Pumping test duration [s]	Water level [ft]	Drawdown [ft]	
1	0	6.63	0.47	
2	1	6.48	0.32	
3	2	6.19	0.03	
4	3	6.22	0.06	
5	4	6.22	0.06	
6	5	6.20	0.04	
7	6	6.20	0.04	
8	7	6.19	0.03	
9	8	6.19	0.03	
10	9	6.19	0.03	
11	10	6.18	0.02	
12	11	6.18	0.02	
13	12	6.18	0.02	
14	13	6.18	0.02	
15	14	6.18	0.02	
16	15	6.17	0.01	
17	16	6.18	0.02	
18	17	6.18	0.02	
19	18	6.18	0.02	
20	19	6.17	0.01	
21	20	6.17	0.01	
22	21	6.17	0.01	
23	22	6.17	0.01	
24	23	6.17	0.01	
25	24	6.17	0.01	
26	25	6.17	0.01	
27	26	6.17	0.01	
28	27	6.17	0.01	
29	28	6.17	0.01	
30	29	6.17	0.01	
31	30	6.17	0.01	
32	31	6.17	0.01	
33	32	6.17	0.01	
34	33	6.17	0.01	
35	34	6.17	0.01	
36	35	6.17	0.01	
37	36	6.17	0.01	
38	37	6.17	0.01	
39	38	6.17	0.01	
40	39	6.17	0.01	
41	40	6.17	0.01	
42	41	6.17	0.01	
43	42	6.17	0.01	
44	43	6.17	0.01	
45	44	6.17	0.01	
46	45	6.17	0.01	
47	46	6.17	0.01	
48	47	6.16	0.00	
49	48	6.17	0.01	
50	49	6.17	0.01	

ERM-West. Inc. 455 Capitol Mall, Suite 800 Sacramento, CA 95814 ph.(916)444-9378	slug/bail test analysis BOUWER-RICE's method	Page 1 Project: Seattle ANGS RI Evaluated by: fjl Date: 9/24/97

Slug Test No. Slug In #2	Test conducted on: 5/2/97
MW-3	



Hydraulic conductivity [ft/s]: 1.25×10^{-4}

ERM-West. Inc. 455 Capitol Mall, Suite 800 Sacramento, CA 95814 ph.(916)444-9378	slug/bail test analysis BOUWER-RICE's method	Page 2 Project: Seattle ANGS RI Evaluated by: fjl — Date: 9/24/97

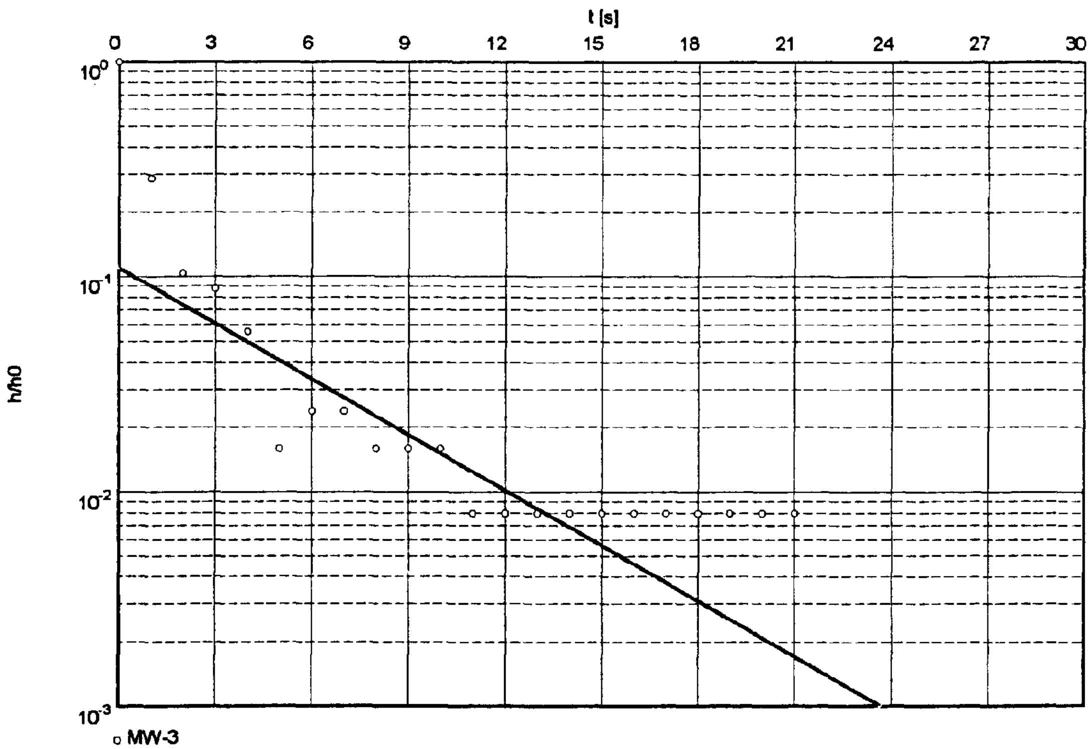
Slug Test No. Slug In #2	Test conducted on: 5/2/97
MW-3	MW-3

Static water level: 6.16 ft below datum

	Pumping test duration [s]	Water level [ft]	Drawdown [ft]	
1	0	4.66	-1.50	
2	1	6.02	-0.14	
3	3	6.08	-0.08	
4	4	6.07	-0.09	
5	5	6.11	-0.05	
6	6	6.13	-0.03	
7	7	6.13	-0.03	
8	8	6.12	-0.04	
9	9	6.13	-0.03	
10	10	6.14	-0.02	
11	11	6.14	-0.02	
12	12	6.13	-0.03	
13	13	6.14	-0.02	
14	14	6.15	-0.01	
15	15	6.15	-0.01	
16	16	6.15	-0.01	
17	17	6.15	-0.01	
18	18	6.15	-0.01	
19	19	6.15	-0.01	
20	20	6.15	-0.01	
21	21	6.15	-0.01	
22	22	6.15	-0.01	
23	23	6.15	-0.01	
24	24	6.15	-0.01	
25	25	6.15	-0.01	
26	26	6.16	0.00	
27	27	6.15	-0.01	
28	28	6.15	-0.01	
29	29	6.16	0.00	
30	30	6.15	-0.01	
31	31	6.15	-0.01	
32	32	6.15	-0.01	
33	33	6.16	0.00	
34	34	6.16	0.00	

ERM-West. Inc. 455 Capitol Mall, Suite 800 Sacramento, CA 95814 ph.(916)444-9378	slug/bail test analysis BOUWER-RICE's method	Page 1 Project: Seattle ANGS RI Evaluated by: fjl — Date: 9/24/97

Slug Test No. Slug Out #2	Test conducted on: 5/2/97
MW-3	



Hydraulic conductivity [ft/s]: 2.22×10^{-4}

ERM-West. Inc. 455 Capitol Mall, Suite 800 Sacramento, CA 95814 ph.(916)444-9378	slug/bail test analysis BOUWER-RICE's method	Page 2 Project: Seattle ANGS RI Evaluated by: fjl — Date: 9/24/97

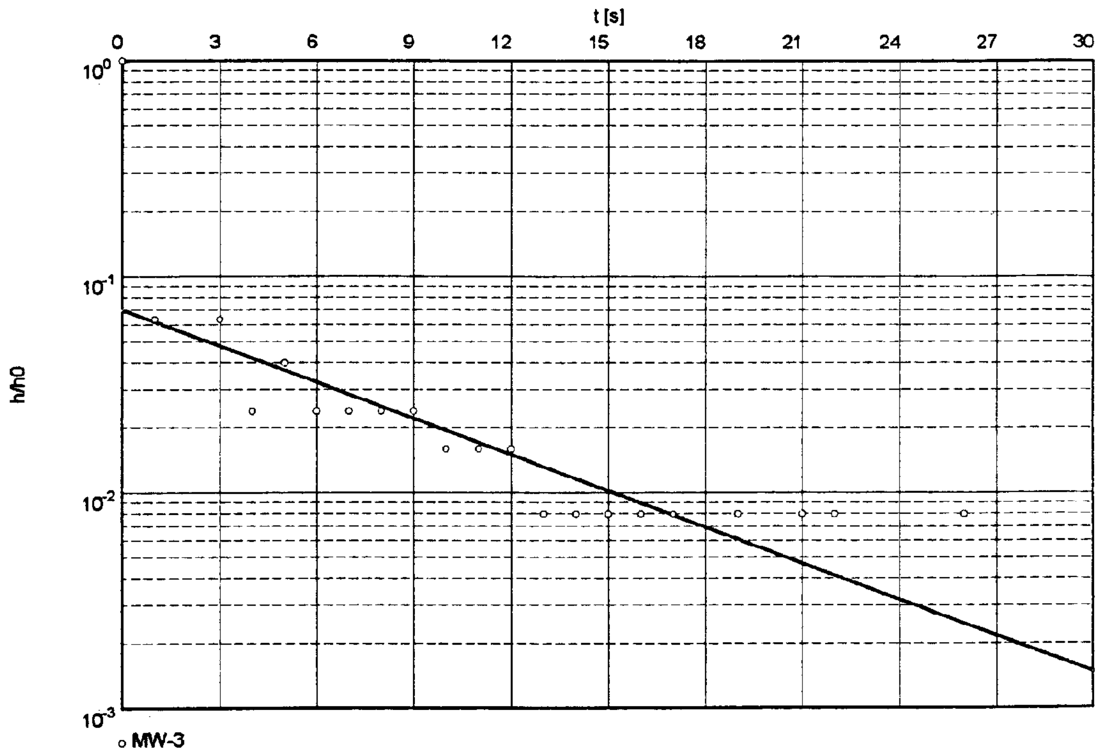
Slug Test No. Slug Out #2	Test conducted on: 5/2/97
MW-3	MW-3

Static water level: 6.16 ft below datum

	Pumping test duration [s]	Water level [ft]	Drawdown [ft]	
1	0	7.42	1.26	
2	1	6.52	0.36	
3	2	6.03	-0.13	
4	3	6.27	0.11	
5	4	6.23	0.07	
6	5	6.18	0.02	
7	6	6.19	0.03	
8	7	6.19	0.03	
9	8	6.18	0.02	
10	9	6.18	0.02	
11	10	6.18	0.02	
12	11	6.17	0.01	
13	12	6.17	0.01	
14	13	6.17	0.01	
15	14	6.17	0.01	
16	15	6.17	0.01	
17	16	6.17	0.01	
18	17	6.17	0.01	
19	18	6.17	0.01	
20	19	6.17	0.01	
21	20	6.17	0.01	
22	21	6.17	0.01	
23	22	6.16	0.00	

ERM-West. Inc. 455 Capitol Mall, Suite 800 Sacramento, CA 95814 ph.(916)444-9378	slug/bail test analysis BOUWER-RICE's method	Page 1 Project: Seattle ANGS RI Evaluated by: fjl · Date: 9/24/97

Slug Test No. Slug In #3	Test conducted on: 5/2/97
MW-3	



Hydraulic conductivity [ft/s]: 1.31×10^{-4}

ERM
ERM-West. Inc.
455 Capitol Mall, Suite 800
Sacramento, CA 95814
ph.(916)444-9378

slug/bail test analysis
BOUWER-RICE's method

Project: Seattle ANGS RI

Evaluated by: fjl | Date: 9/24/97

Slug Test No. Slug In #3 | Test conducted on: 5/2/97

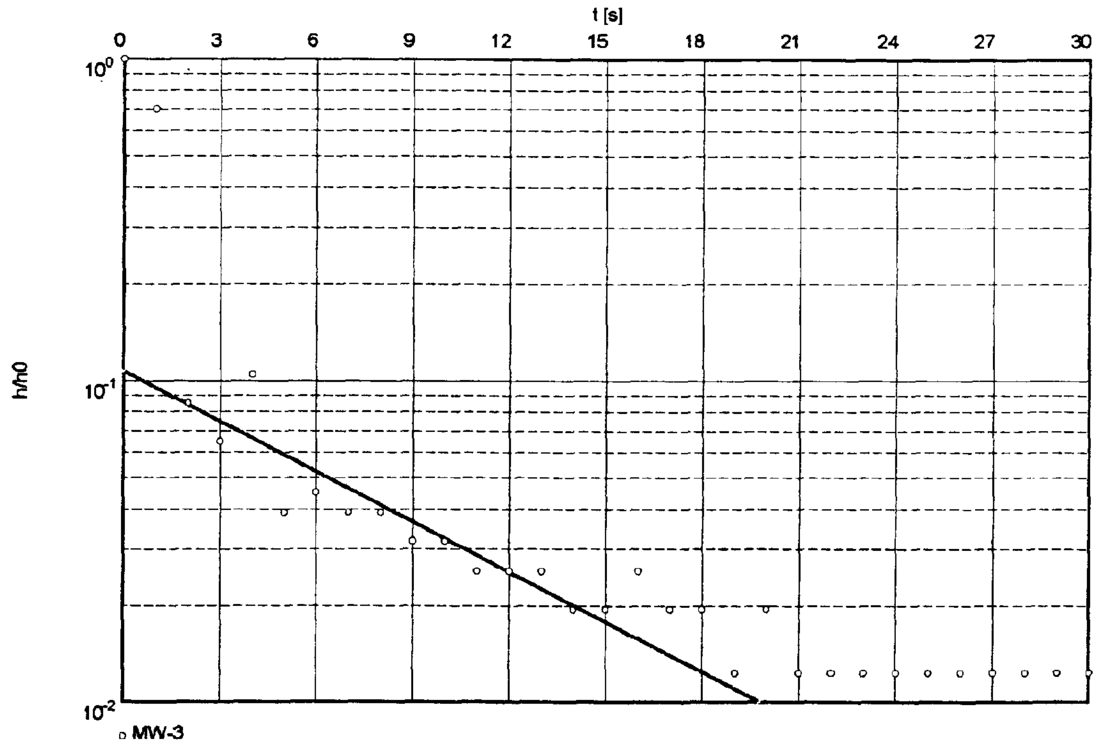
MW-3 | MW-3

Static water level: 6.16 ft below datum

	Pumping test duration [s]	Water level [ft]	Drawdown [ft]	
1	0	4.90	-1.26	
2	1	6.08	-0.08	
3	3	6.08	-0.08	
4	4	6.13	-0.03	
5	5	6.11	-0.05	
6	6	6.13	-0.03	
7	7	6.13	-0.03	
8	8	6.13	-0.03	
9	9	6.13	-0.03	
10	10	6.14	-0.02	
11	11	6.14	-0.02	
12	12	6.14	-0.02	
13	13	6.15	-0.01	
14	14	6.15	-0.01	
15	15	6.15	-0.01	
16	16	6.15	-0.01	
17	17	6.15	-0.01	
18	18	6.16	0.00	
19	19	6.15	-0.01	
20	20	6.16	0.00	
21	21	6.15	-0.01	
22	22	6.15	-0.01	
23	23	6.16	0.00	
24	24	6.16	0.00	
25	25	6.16	0.00	
26	26	6.15	-0.01	
27	27	6.16	0.00	
28	28	6.16	0.00	
29	29	6.16	0.00	
30	30	6.16	0.00	

ERM-West, Inc. 455 Capitol Mall, Suite 800 Sacramento, CA 95814 ph.(916)444-9378	slug/bail test analysis BOUWER-RICE's method	Page 1	
		Project: Seatle ANGS RI	
		Evaluated by: fjl	Date: 9/24/97

Slug Test No. Slug Out #3	Test conducted on: 5/2/97
MW-3	



Hydraulic conductivity [ft/s]: 6.09×10^{-4}

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ERM-West. Inc. 455 Capitol Mall, Suite 800 Sacramento, CA 95814 ph.(916)444-9378	slug/bail test analysis BOUWER-RICE's method	Page 2
		Project: Seatle ANGS RI
		Evaluated by: fjl · Date: 9/24/97

Slug Test No. Slug Out #3	Test conducted on: 5/2/97
MW-3	MW-3

Static water level: 6.16 ft below datum

	Pumping test duration [s]	Water level [ft]	Drawdown [ft]	
1	0	7.14	0.97	
2	1	6.84	0.68	
3	2	6.08	-0.08	
4	3	6.22	0.06	
5	4	6.26	0.10	
6	5	6.20	0.04	
7	6	6.20	0.04	
8	7	6.20	0.04	
9	8	6.20	0.04	
10	9	6.19	0.03	
11	10	6.19	0.03	
12	11	6.18	0.02	
13	12	6.18	0.02	
14	13	6.18	0.02	
15	14	6.18	0.02	
16	15	6.18	0.02	
17	16	6.18	0.02	
18	17	6.18	0.02	
19	18	6.18	0.02	
20	19	6.17	0.01	
21	20	6.18	0.02	
22	21	6.17	0.01	
23	22	6.17	0.01	
24	23	6.17	0.01	
25	24	6.17	0.01	
26	25	6.17	0.01	
27	26	6.17	0.01	
28	27	6.17	0.01	
29	28	6.17	0.01	
30	29	6.17	0.01	
31	30	6.17	0.01	

APPENDIX F

REPOSITORIES OF LABORATORY ANALYTICAL DATA PACKAGES

Copies of the complete laboratory analytical data packages are available for public examination at three storage repositories. The repository location, address, and appropriate contact persons are listed below:

Repository Location	Address	Contact Person, Phone Number, and Facsimile Number
Washington Air National Guard, Tacoma, Washington	241 CES/CEV 104 Air Defense Lane Camp Murray, Washington 98430-5022	Mr. Stephen Purvine Phone: 253-512-3205 Facsimile: 253-512-3200
Air National Guard/CEVR/HQ	Building R-47 3500 Fetchet Avenue Andrews Air Force Base, Maryland 20762	Mr. Alan Klavans Phone: 301-836-8451 Facsimile: 301-836-8121
Environmental Resources Management	915 - 118th Avenue SE Suite 130 Bellevue, Washington 98005	Dr. Robert C. Leet Phone: 425-462-8591 Facsimile: 425-455-3573

APPENDIX G

TPH FIELD-SCREENING RESULTS

Data Sheet for PETRO RISc® SamplePro Test

LOT 60827 | EXP. DATE 06/29/97 | PAGE 1 OF 4

Operator: FRANK LAMPHERE Date: 15 OCT. 1996 Location: SEATTLE ANGS

Sample ID	Low Test Level ΔOD	OD sample	Interpretation	High Test Level ΔOD	OD sample	Interpretation	Comments
	Standards	15 ppm		Standards	100 ppm		
SB-1-3	-0.01	0.41	≤ 15 ppm	-0.03	0.49	< 100 ppm	
SB-1-5	-0.01	0.59	< 15 ppm	-0.03	0.71	< 100 ppm	
SB-1-7	-0.01	0.66	< 15 ppm	-0.03	0.62	< 100 ppm	
SB-1-9	-0.01	0.62	< 15 ppm	-0.03	0.41	< 100 ppm	
			FJZ	10-15-96			
SB-2-5	-0.26	-0.11	> 15 ppm	-0.09	0.28	< 100 ppm	
SB-2-7	-0.26	0.25	< 15 ppm	-0.09	0.43	< 100 ppm	
SB-2-9	-0.26	0.13	< 15 ppm	-0.09	0.77	< 100 ppm	
SB-2-11	-0.26	0.41	< 15 ppm	-0.09	0.89	< 100 ppm	
			FJZ	10-15-96			
SB-3-3	-0.26	-0.21	> 15 ppm	-0.16	0.54	< 100 ppm	
SB-3-5	-0.26	-0.32	> 15 ppm	-0.16	0.45	< 100 ppm	
SB-3-7	-0.26	-0.01	> 15 ppm	-0.16	0.31	< 100 ppm	
SB-3-9	-0.26	-0.27	> 15 ppm	-0.16	0.40	< 100 ppm	
			FJZ	10-15-96			
SB-4-3	-0.05	-0.08	> 15 ppm	-0.03	0.12	< 100 ppm	
SB-4-5	-0.05	-0.18	> 15 ppm	-0.03	0.55	< 100 ppm	
SB-4-7	-0.05	-0.10	> 15 ppm	-0.03	0.19	< 100 ppm	
SB-4-9	-0.05	0.58	< 15 ppm	-0.03	0.73	< 100 ppm	
			FJZ	10-16-96			
SB-5-3	-0.08	-0.15	> 15 ppm	-0.00	0.31	< 100 ppm	
SB-5-5	-0.08	0.28	≤ 15 ppm	-0.00	0.42	< 100 ppm	
SB-5-7	-0.08	0.16	< 15 ppm	-0.00	0.40	< 100 ppm	
SB-5-9	-0.08	0.17	≤ 15 ppm	-0.00	0.66	< 100 ppm	

SEATTLE "UG" TP... EL... ...R... U

Data Sheet for PETRO RISC® SamplePro Test

LOT 60827 | PAGE 2 OF 4

Operator: FRANK LAMPHERE Date: 10:16:96 Location: SEATTLE ANGS

	Low Test Level			High Test Level			
Sample ID	ΔOD	OD sample	Interpretation	ΔOD	OD sample	Interpretation	Comments
	Standards	15 ppm		Standards	100 ppm	–	
SB-6-3	-0.11	0.09	<15ppm	-0.11	0.54	<100ppm	
SB-6-5	-0.11	0.13	<15ppm	-0.11	0.15	<100ppm	
SB-6-7	-0.11	0.17	<15ppm	-0.11	0.54	<100ppm	
SB-6-9	-0.11	0.46	<15ppm	-0.11	0.52	<100ppm	
START LOT # ~~704~~ 30 60827							
SB-7-3	-0.12	0.04	<15ppm	-0.29	0.57	<100ppm	
SB-7-5	-0.12	0.37	<15ppm	-0.29	0.48	<100ppm	
SB-7-7	-0.12	-0.27	>15ppm	-0.29	0.01	<100ppm	
SB-7-9	-0.12	0.19	<15ppm	-0.29	0.56	<100ppm	
			~~FR~~	~~10-16-96~~			
7-46 SB-8-3	-0.24	-0.04	>15ppm	-0.00	0.47	<100ppm	10.17.96
SB-8-5	-0.24	-0.01	>15ppm	-0.00	0.85	<100ppm	
SB-8-7	-0.24	0.43	<15ppm	-0.00	0.70	<100ppm	
SB-8-9	-0.24	0.41	<15ppm	-0.00	0.91	<100ppm	
SB-9-3	-0.11	-0.02	>15ppm	-0.05	0.55	<100ppm	
SB-9-5	-0.11	0.01	<15ppm	-0.05	0.25	<100ppm	
SB-9-7	-0.11	-0.09	>15ppm	-0.05	0.73	<100ppm	
SB-9-9	-0.11	-0.02	>15ppm	-0.05	0.53	<100ppm	
SB-10-3	-0.02	0.31	<15ppm	-0.10	-0.08	>100ppm	? ?
SB-10-5	-0.02	0.35	<15ppm	-0.10	0.59	<100ppm	
SB-10-7	-0.02	0.00	<15ppm	-0.10	0.41	<100ppm	
SB-10-9	-0.02	0.36	<15ppm	-0.10	0.23	<100ppm	

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SEA407330

Data Sheet for PETRO RISC® SamplePro Test

LOT ~~60827~~ 60827

PAGE 3 OF 4

Operator: FRANK SAMPHERE Date: 10.17.96 Location: SEATTLEANGS

Sample ID	Low Test Level ΔOD Standards	Low Test Level OD sample 15 ppm	Low Test Level Interpretation	High Test Level ΔOD Standards	High Test Level OD sample 100 ppm	High Test Level Interpretation	Comments
SB-11-3	-0.09	-0.08	>15ppm	-0.07	0.62	<100ppm	
SB-11-5	-0.09	0.41	<15ppm	-0.07	0.60	<100 ppm	
SB-11-7	-0.09	0.30	<15ppm	-0.07	0.84	<100 ppm	
SB-11-9	-0.09	0.39	<15ppm	-0.07	0.44	<100 ppm	
MW1-5	-0.03	0.08	<15ppm	-0.06	0.11	<100 ppm	
MW1-9	-0.03	-0.03	>15ppm	-0.06	0.25	<100 ppm	
MW2-7	-0.03	-0.05	>15ppm	-0.06	0.18	<100 ppm	
MW2-9	-0.03	-0.05	>15ppm	-0.06	0.65	<100 ppm	
							LOT 60827
MW3-5	-0.36	-0.64	>15ppm*	-0.05	0.17	<100ppm	*Standard above QC limit
MW3-9	-0.36	-0.19	>15ppm*	-0.05	0.68	<100ppm	
MW4-5	-0.36	0.13	<15ppm*	-0.05	0.19	<100ppm	
MW4-9	-0.36	0.22	<15ppm*	-0.05	0.78	<100ppm	
MW5-5	-0.12	0.72	<15ppm	-0.14	0.61	<100ppm	
MW5-9	-0.12	-0.22	>15ppm	-0.14	0.57	<100ppm	PID HEADSPACE
SS-1-0.5	-0.12	0.26	<15ppm	-0.14	0.64	<100ppm	0.1
SS-2-0.5	-0.12	-0.00	>15ppm	-0.14	0.74	<100ppm	0.1
							~~0.1~~
SS-3-0.5	-0.22	0.47	<15ppm	-0.08	0.72	<100 ppm	0.1
SS-4-0.5	-0.22	0.53	<15ppm	-0.08	0.84	<100 ppm	0.3
SS-5-0.5	-0.22	-0.01	>15ppm	-0.08	0.65	<100 ppm	0.3
SS-6-0.5	-0.22	-0.09	>15ppm	-0.08	0.80	<100 ppm	0.3

KCSlip4 40801

SEA407331

Data Sheet for PETRO RISc® SamplePro Test

LOT 60827

PAGE 4 OF 4

Operator: FRANK LAMPHERE Date: 10.17.96 Location: Seattle ARGC

Sample ID	Low Test Level ΔOD Standards	OD sample 15 ppm	Interpretation	High Test Level ΔOD Standards	OD sample 100 ppm	Interpretation	Comments	PID
SS-7-0.5	-0.09	0.11	<15ppm	-0.13	0.47	<100ppm		0.1
SS-8-0.5	-0.09	0.30	<15ppm	-0.13	0.63	<100ppm		0.1
SS-9-0.5	-0.09	0.02	<15ppm	-0.13	0.68	<100ppm		0.1
SS-10-0.5	-0.09	0.40	<15ppm	-0.13	0.17	<100ppm		0.1

KCSlip4 40802

SEA407332

APPENDIX H

WDOE LETTER REGARDING RADIONUCLIDES IN SOIL

STATE OF WASHINGTON
DEPARTMENT OF HEALTH
DIVISION OF RADIATION PROTECTION
Airdustrial Center, Bldg. 5 • P.O. Box 47827 • Olympia, Washington 98504-7827

ERS 97-506

May 9, 1997

Steve Becker
ERM-West Inc.
455 Capitol Mall, Suite 800
Sacramento, California 95814

Dear Mr. Becker:

We have reviewed the data on the sheets attached to your April 15, 1997 memorandum. The radioactive material in these samples is of natural origin. All of the isotopes detected, with the exception of K-40, are in the U-238 or Th-232 decay chains. All radioisotopes are at background levels.

On the basis of this data the soil may be treated as non-radioactive. The soil cuttings may be treated and disposed without regard to radiological concerns.

Based on the explanation of the past use of this site, and supported by this data, we have reached several other conclusions:

1. While it is possible that various pieces of equipment that were stored and serviced at the site contained components that had small amounts of radioactive material in them, there is no evidence that those components were disposed of on site.

2. Assuming those components were disposed of on site, the radioactive material would not enter the environment unless the component was broken and the material spread or washed out. There is no evidence that this happened.

3. There is no need for you to do radiological testing on future soil samples or digging spoils generated at this site.

If you have any further questions, please call me at (360)586-3306, or Mike Brennan at (360)753-3349.

Sincerely,

Michael Brennan for

Debra McBaugh, Head
Environmental Radiation Section